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Osaka, this 1st day of July , 1999

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[Name of the Document] Specification

[Title of the Invention] Optical Recording and Reproduction Apparatus

[Claims]

[Claim 1] An optical recording and reproduction apparatus comprising: focusing means for dividing a light beam into plural beams, and focusing the light beams on recording media having different base material thicknesses; moving means for moving a focal point of each of the light beams focused by the focusing means in a direction substantially perpendicular to the surface of each recording medium; focusing state detecting means for generating a signal corresponding to the focusing state of each light beam on the recording medium; and focus control means for driving the moving means in accordance with the output signal from the focusing state detecting means to control any of the divided light beams on the recording media so that it enters a predetermined focusing state; wherein, when starting or resuming the apparatus, said moving means is driven to make the focal point of each light beam go away from the recording medium or approach the recording medium, and said focus control means is operated for the focal point of a light beam which arrives or passes the information face of the recording medium first, amongst the focal points of the divided light beams.

[Claim 2] An optical recording and reproduction apparatus as described in Claim 1 wherein, in the case of a recording medium

having a thin base material, the moving means is driven so that it goes away from the recording medium, and the focus control means is operated for a light beam which arrives or passes the information face first during the going-away; and in the case of a recording medium having a thick base material, the moving means is driven so that it approaches the medium, and the focus control means is operated for a light beam which arrives or passes the information face first during the approach.

[Claim 3] An optical recording and reproduction apparatus as described in Claim 2 wherein, in the case of a CD, the focus control means is operated for a light beam which arrives the information face first during the approach; and in the case of a recording medium having a base material thinner than that of the CD, the focus control means is operated for a light beam which arrives the information face first during the going-away.

[Claim 4] An optical recording and reproduction apparatus as described in Claim 1 wherein, when each of the divided light beams is made to go away from the recording medium or approach the recording medium, the light beam is previously moved to a position where the focal point of the light beam is sufficiently distant from the information face of the recording medium and, thereafter, the light beam is made to go away from or approach the information face.

[Claim 5] An optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on a

recording medium having at least two layers of information faces; moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium; focus control means for driving the moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; and lead-in face detecting means for detecting an information face of the recording medium at which the focal point of the light beam arrives first, when the moving means is driven at starting or resuming of the apparatus such that the focal point of the light beam is made to come sufficiently close to the recording medium and then it is made to go away from the recording medium; wherein said focus control means is operated in accordance with a signal output from the lead-in face detecting means.

[Claim 6] An optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on a recording medium having at least two layers of information faces; moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; focusing state detecting means for generating a signal corresponding to the focusing state

of the light beam on the recording medium; focus control means for driving the moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; and focus jumping means for making the focus control means go from the operating state to the non-operating state, and driving the moving means to move the focal point of the light beam from the first information face to the second information face of the recording medium; and said focus jumping means comprising: accelerating means for accelerating the moving speed of the focal point of the light beam in accordance with the signal output from the focusing state detecting means; decelerating means for decelerating the moving speed of the focal point of the light beam; and jumping lead-in means for detecting that the light beam arrives a target information face by that the signal output from the focusing state detecting means reaches a predetermined level, thereby operating the focus control means.

[Claim 7] An optical recording and reproduction apparatus as described in Claim 6 further comprising: S signal measuring means for measuring the amplitude of the signal output from the focusing state detecting means every time the focal point of the light beam passes each information face when the moving means is driven at starting or resuming the apparatus such that the focal point of the light beam is made to approach the recording medium and then go away from the medium or it is made to go away from

the recording medium and then approach the medium; and gain change means for changing the gain of the focusing state detecting means so that it becomes optimum at each information face, according to each of the amplitudes measured by the S signal measuring means; and said jumping lead-in means detecting that the focal point of the light beam arrives each information face of the recording medium by that the signal from the focusing state detecting means, which has passed the gain change means, reaches a predetermined level, in accordance with the amplitudes measured by the S signal measuring means, thereby resuming the focus control means.

[Claim 8] An optical recording and reproduction apparatus as described in Claim 6 further comprising: light quantity signal measuring means for measuring the amplitude of a signal according to the quantity of reflected light from the recording medium every time the focal point of the light beam passes each information face when the moving means is driven at starting or resuming the apparatus such that the focusing means is made to approach the recording medium and then go away from the medium or it is made to go away from the recording medium and then approach the medium; and gain change means for changing the gain of the focusing state detecting means so that it becomes optimum at each information face, according to each of the amplitudes measured by the light quantity signal measuring means; and said jumping lead-in means detecting that the focal point of the light beam arrives

each information face of the recording medium by that the signal from the focusing state detecting means, which has passed the gain change means, reaches a predetermined level, in accordance with the amplitudes measured by the light quantity signal measuring means, thereby resuming the focus control means.

[Claim 9] An optical recording and reproduction apparatus as described in Claim 6 wherein, when amplitudes or integrated values of an accelerating signal and a decelerating signal which are generated by the accelerating means and the decelerating means, respectively, are set so that these signals have the relationship of "accelerating signal > decelerating signal" when the focal point of the light beam moves from the surface of the recording medium to an inner side information face, and have the relationship of "accelerating signal < decelerating signal" when the focal point of the light beam moves from inside of the recording medium to a surface side information face.

[Claim 10] An optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on a recording medium having tracks on which concave and convex signals corresponding to pit parts and mirror parts are recorded in advance; first signal detecting means for detecting a first signal which becomes large when the light beam focused by the focusing means deviates in the positive direction from the recording medium; second signal detecting means for detecting a second signal which becomes large when the light beam focused by

the focusing means deviates in the negative direction from the recording medium; first and second peak hold means for peak-holding parts of the first and second signal detecting means corresponding to the mirror parts, respectively; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium in accordance with first and second peak hold signals; moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; and focus control means for driving the moving means according to the output signal from the focusing state detecting means so that the focus position of the light beam on the recording medium becomes approximately constant.

[Claim 11] An optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on a recording medium having plural layers of information faces; first moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; second moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium and the direction of tracks; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium; track error detecting means for generating a signal corresponding

to the positional relationship between the focal point of the light beam on the recording medium and a track; focus control means for driving the first moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; tracking control means for driving the second moving means in accordance with the output signal from the track error detecting means to control the focal point of the light beam on the recording medium so that it correctly scans the tracks; focus jumping means for making the focus control means go from the operating state to the non-operating state, and driving the moving means to move the focal point of the light beam from an information face to another information face of the recording medium; learning means for operating the focus control means and the tracking control means in each information face of the recording medium at starting of the apparatus, and learning and selecting set values required in the focus control means and the tracking control means; and storage means for storing the set values; and said learning means being constructed so that it selects a set value for a target information face from the set values stored in the storage means, when the light beam is moved to the target information face by the focus jumping means after learning in each information face.

[Claim 12] An optical recording and reproduction apparatus as described in Claim 11 wherein said learning means comprises:

eccentricity measuring means for measuring the quantity of eccentricity on each information face of the recording medium; and eccentricity correction value calculating means for obtaining a correction value to be added to or subtracted from the signal from the tracking control means, in accordance with the measured value by the eccentricity measuring means; and the set values in the learning means are information obtained in the eccentricity correction value calculating means.

[Claim 13] An optical recording and reproduction apparatus as described in Claim 11 wherein said learning means comprises: focus offset measuring means for obtaining an offset of the focus control means in accordance with one of an amplitude, a jitter, an error rate, and a C/N, of a reproduced signal on each information face of the recording medium; and focus offset correcting means for correcting the offset by adding or subtracting to/from the signal from the focus control means, in accordance with the offset value from the focus offset measuring means; and the set values in the learning means are correction values from the focus offset correction means.

[Claim 14] An optical recording and reproduction apparatus as described in Claim 11 wherein said learning means comprises: tracking offset measuring means for obtaining an offset of the tracking control means in accordance with a reproduced signal on each information face of the recording medium or a signal from the track error detecting means; and tracking offset correcting

means for correcting the offset by adding or subtracting to/from the signal from the tracking control means, in accordance with the offset value from the tracking offset measuring means; and the set values in the learning means are correction values from the tracking offset correction means.

[Claim 15] An optical recording and reproduction apparatus as described in Claim 11 wherein said learning means comprises: gain measuring means for measuring a loop gain of the focus control means or the tracking control means; and gain change means for changing the loop gain of the focus control means or the tracking control means to an optimum value, in accordance with a signal from the gain measuring means; and the set values in the learning means are optimum values set by the gain change means.

[Claim 16] An optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on plural recording media having different base material thicknesses; first moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surfaces of the recording media; second moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surfaces of the recording media and the direction of tracks; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on each of the recording media; track error detecting means for generating a signal

corresponding to the positional relationship between the focal point of the light beam on the recording medium and a track; focus control means for driving the first moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; tracking control means for driving the second moving means in accordance with the output signal from the track error detecting means to control the focal point of the light beam on the recording medium so that it correctly scans the tracks; light quantity signal measuring means for measuring the amplitude of a signal according to the quantity of reflected light from the recording medium every time the focal point of the light beam passes each information face when the moving means is driven at starting or resuming the apparatus such that the focusing means is made to approach the recording medium and then go away from the medium or it is made to go away from the recording medium and then approach the medium; recording medium judge means for judging the kind of the recording medium loaded in the apparatus in accordance with the signals from the light quantity signal measuring means or the focusing state detecting means; and a storage means for storing set values relating to the focus control means and the tracking control means, according to the signal from the recording medium judge means; wherein, if the focus control means or the tracking control means does not operate normally, the set values which are

set according to the disk judge means and stored in the storage means, are changed to set values of another recording medium.

[Claim 17] An optical recording and reproduction apparatus as described in Claim 16 wherein, in the case where the recording medium judge means decides that the loaded medium is a CD and therefore set values for the CD are stored in the storage means, if the focus control means/or the tracking control means does not operate normally, setting in the storage means is changed to setting of a DVD.

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention]

The present invention relates to an optical recording and reproduction apparatus which optically records signals in a recording medium and reproduces the recorded signals by using a light beam emitted from a light source, such as a laser. More specifically, the invention relates to an optical recording and reproduction apparatus equipped with a focus control unit which controls the focusing state of the light beam irradiating the recording medium so that it becomes a predetermined focusing state.

[0002]

[Prior Art]

As a conventional optical recording and reproduction apparatus, there is an optical recording and reproduction

apparatus disclosed in Japanese Published Patent Application No. Hei. 7-129968, in which a light beam emitted from a light source, such as a semiconductor laser, is focused on a disk type recording medium rotating at a predetermined speed to record or reproduce signals. This recording medium has spiral or concentric micro-tracks having a width of about 0.6μm and a pitch of about 1.5μm. In order to record signals on the tracks or reproduce signals recorded on the tracks, in the optical recording and reproduction apparatus, focus control is performed so that the light beam irradiating the recording medium is in a predetermined focused state.

[0003]

Figure 19 is a block diagram illustrating a simple structure of an optical recording and reproduction apparatus including a conventional focus control unit. Hereinafter, the conventional focus control unit will be described.

[0004]

As shown in the figure, the conventional recording and reproduction apparatus comprises a light source 1 such as a semiconductor laser, a coupling lens 2, a polarization beam splitter 3, a polarizing plate 4, and a focusing lens 5 (components of an optical system for irradiating a disk 7 as a recording medium with a light beam 8), and a disk motor 6 for rotating the disk 7 at a predetermined rotation speed. The light beam 8 emitted from the light source 1 is collimated by the

coupling lens 2. The collimated light is reflected by the polarization beam splitter 3 to the polarizing plate 4, travels through the polarizing plate 4, and is focused by the focusing lens 5 to be applied to the disk 7 rotated by the disk motor 6.

[0005]

This optical recording and reproduction apparatus further comprises a condenser lens 9 and a split mirror 10 as elements receiving the light beam reflected at the disk 7. The reflected light beam from the disk 7 travels through the focusing lens 5, polarizing plate 4, and the polarization beam splitter 3, and is split into two beams 11 and 15 in two directions by the split mirror 10 via the condenser lens 9. These light beams 11 and 15 are applied to a focus control unit and a tracking control unit, respectively.

[0006]

The focus control unit comprises a photodetector 12 divided into two parts, preamplifiers 13A and 13B, a differential amplifier 14, a phase compensator 18, a linear motor 19, a switch 33, a driving circuit 35, a focus control element (focus actuator) 36, a logic circuit 40, a comparator 41, and a chopping wave generator 42. The photodetector 12 has two light responsive parts A and B. Output signals from the light responsive parts A and B are amplified by the preamplifiers 13A and 13B, respectively, to be input to the differential amplifier 14. A knife edge detection method is realized by the condenser lens 9

and the split mirror 10, and an output signal from the differential amplifier 14 becomes a focus error signal (FE).

[0007]

The phase of the FE in the focus control system is compensated by the phase compensator 18, and it is input to the driving circuit 35 via the switch 33 to close a loop of the focus control system. When the focus control system is in the closed state by the switch 33, the driving circuit 35 power-amplifies the FE from the phase compensator 18 and outputs it to the focus control element 36. In this structure, when the focus control system is in the closed state, the focus control element 36 is driven so that the light beam on the disk is always in a predetermined focused state. Further, an output signal from the chopping wave generator 42 is also input to the switch 33. Further, the FE is also input to the logic circuit 40 through the comparator 41. The logic circuit 40 controls the open/close operation of the switch 33.

[0008]

The linear motor 19 moves the focusing lens 5, the focus control element 36, the polarization beam splitter 3, etc., in the direction transverse to the tracks on the disk 7, and this is usually operated when moving the focal point of the light beam onto a predetermined track.

[0009]

On the other hand, the other light beam 15 from the split

mirror 10 is input to the photodetector 16 divided into two parts, in the tracking servo system. The photodetector 16 has two light responsive parts C and D, and a difference between output signals from the respective light responsive parts C and D is a track error signal (TE) for controlling the light beam on the disk 7 so that it correctly scans the tracks. Since tracking control does not directly relate to the present invention, detailed description thereof is omitted here, and necessary description will be given in the section of EMBODIMENTS OF THE INVENTION.

[0010]

In the optical recording and reproduction apparatus with the focus control unit so constructed, focus control is performed as follows.

[0011]

Initially, the disk 7 is rotated by the disk motor 6. When a prescribed rotating speed is reached, the switch 33 is placed on the chopping wave generator 42 side, and the focus control element 36 is operated in response to a signal output from the chopping wave generator 42, whereby the focusing lens 5 is moved up and down in the direction perpendicular to the recording face of the disk 7. Thereby, the focal point of the light beam on the disk 7 moves up and down. At this time, an S-shaped FE (hereinafter referred to as "S signal") which appears when the focal point of the light beam passes the recording face, is detected by the comparator 41. By detecting the S signal, the

logic circuit 40 can know whether the focal point of the light beam is positioned in the vicinity of the recording face or not. When the focus is positioned in the vicinity of the recording face, the switch 33 is placed on the phase compensator 18 side. By closing the focus servo loop in this way, focus control (focus lead-in) is performed so that the light beam is focused on a prescribed optimum target position.

[0012]

The focus lead-in operation will be described with reference to figures 20, 21, and 22. Figure 20 illustrates a waveform of a focusing lens driving signal and a waveform of an S signal which appears in the FE. Figure 21 illustrates a waveform indicating the relationship between the lead-in level and S signals in the protection film at the surface of the disk 7 and in the recording film, which S signals appear in the FE when the focusing lens 5 is made to come close to or go away from the disk 7. Figure 22 is a simple flowchart showing a fundamental focus lead-in procedure in the focus control unit.

[0013]

As shown in figure 22, when the power is applied to the reading and reproducing apparatus, the disk motor 6 is turned on, and the disk 7 is rotated, in step S21. When the disk 7 reaches a predetermined rotating speed, the light source 1 is turned on, and, for example, a semiconductor laser emits light, in step S22. Subsequently, in step S23, the linear motor 19 is operated to

move the focusing lens 5 toward the inner circumference of the disk 7. When the above-mentioned initial operation has ended, focus lead-in operation takes place.

[0014]

Initially, as shown in figure 20, the focusing lens 5 is moved down to make it away from the disk 7 in accordance with an output signal from the chopping wave generator 42, in step S24. Then, in step S25, the focusing lens 5 is moved up to bring it close to the disk 7. While repeating the up-and-down operation of the focusing lens 5, it is detected that the S signal has reached a predetermined lead-in level in step S26. After the predetermined lead-in level has been reached, the logic circuit 40 places the switch 33 on the phase compensator 18 side, and the up-and-down movement of the focusing lens 5 is stopped in step S27. In step S28, focus control is turned on, and the lead-in operation is ended, whereby focus control is started.

[0015]

The detection level (lead-in level) of the comparator 41 for focus lead-in is specified according to the amplitudes of the S signals which are output due to reflection at the recording film of the disk 7 and the reflection at the protection film, respectively. That is, as shown in figure 21, it is set within a linear interval which is larger than the peak of the S signal at the protection film and is between the peak of the S signal at the recording film and 0.

[0016]

[Problems to be solved by the Invention]

In the conventional optical recording and reproduction control apparatus, the focus control lead-in operation is realized by the method described above.

[0017]

In the conventional method, since an S signal appears every time the focal point of the light beam passes each of information faces of a mass storage disk (for example, a digital vide disk, hereinafter referred to as a DVD) having two or more information faces at each side as shown in figure 6, S signals as may as the information faces appear when the focusing lens is moved up and down during the focus lead-in operation. For example, in a dual-layer DVD, as shown in figure 7, in addition to small S signals on the protection film, two periodic S signals appear on each information face. Therefore, in the conventional focus control system, when the S signals on the surface protection film are detected by mistake, focus control is turned on at that part and focus lead-in ends in failure, or focus control is turned on at the two periodic S signals on the information face, and so which one of the two layers where focus lead-in occurs cannot be known. Therefore, it is very difficult to reproduce information by selecting one of the two information faces certainly and performing focus control and tracking control on the selected information face.

[0018]

Further, in an optical head using a hologram element 106 shown in figure 1 to make compatibility with a CD, two focal points 107a and 107b shown in figure 1 are obtained, and an S signal at each focal point appears at the time of focus lead-in on a disk having one information face like a CD due to influences of these two beams. So, it is difficult to decide which one of the two focal points where focus lead-in should be performed. Further, in a dual-layer DVD, at least six S signals appear in the FE by each UP or DOWN at the time of focus lead-in as shown in figure 6. When surface deflection of the disk is large, the respective S signals interfere with each other and become nonlinear. In this case, it is almost impossible to perform lead-in control by measuring the amplitudes of the S signals to learn the lead-in level and detecting the information face on which focus lead-in should be performed.

[0019]

Furthermore, in a dual-layer disk or a multiple-layer disk, the respective information faces have different eccentricities, focus offset values, tracking offset values, focus gain values, tracking gate values, and focus errors during track seeking. Therefore, even if these correction values are appropriately set for one information face, when the light beam is moved to another information face for reproduction or recording, considerable focus error and track error occur on that information face,

whereby focus control and the tracking control become unstable. Further, when seeking tracks, the focus error becomes large because the light beam crosses the grooves and, therefore, stable seeking cannot be performed.

[0020]

Furthermore, the conventional apparatus is not adapted to various kinds of disks, such as a CD, a single-layer DVD, a dual-layer DVD, and a disk of write once read many type such as a DC-R or a DVD-R. When such disks are loaded in the apparatus, the apparatus indicates errors or the disks are compulsorily ejected.

[0021]

The present invention is made to solve the problems of the above-described prior arts, and proposes a method for performing high-speed and stable focus lead-in control even when a dual-layer disk or a multiple-layer disk is used and a head for irradiating the disk with a light beam has two focuses adapted to disks having different base material thicknesses.

[0022]

It is another object of the present invention to provide a highly reliable optical recording and reproduction apparatus adapted to a dual-layer or multiple-layer disk of large capacity, by proposing a high-speed and stable inter-layer moving method and ensuring performances of stable focusing, tracking, and track seeking in each layer.

[0023]

Further, it is still another object of the present invention to provide a versatile optical recording and reproduction apparatus which can discriminate between various kinds of disks to be loaded, and activate a loaded disk even when the discrimination failed.

[0024]

A first construction of the present invention is an optical recording and reproduction apparatus comprising: focusing means for dividing a light beam into plural beams, and focusing the light beams on recording media having different base material thicknesses; moving means for moving a focal point of each of the light beams focused by the focusing means in a direction substantially perpendicular to the surface of each recording medium; focusing state detecting means for generating a signal corresponding to the focusing state of each light beam on the recording medium; and focus control means for driving the moving means in accordance with the output signal from the focusing state detecting means to control any of the divided light beams on the recording media so that it enters a predetermined focusing state; wherein, when starting or resuming the apparatus, the moving means is driven to make the focal point of each light beam go away from the recording medium or approach the recording medium, and the focus control means is operated for the focal point of a light beam which arrives or passes the information face of the recording medium first, amongst the focal points of

the divided light beams.

[0025]

A second construction of the present invention is an optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on a recording medium having at least two layers of information faces; moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium; focus control means for driving the moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; and lead-in face detecting means for detecting an information face of the recording medium at which the focal point of the light beam arrives first, when the moving means is driven at starting or resuming of the apparatus such that the focal point of the light beam is made to come sufficiently close to the recording medium and then it is made to go away from the recording medium; wherein the focus control means is operated in accordance with a signal output from the lead-in face detecting means.

[0026]

A third construction of the present invention is an optical recording and reproduction apparatus comprising: focusing means

for focusing a light beam on a recording medium having at least two layers of information faces; moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium; focus control means for driving the moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; and focus jumping means for making the focus control means go from the operating state to the non-operating state, and driving the moving means to move the focal point of the light beam from the first information face to the second information face of the recording medium; and the focus jumping means comprising: accelerating means for accelerating the moving speed of the focal point of the light beam in accordance with the signal output from the focusing state detecting means; decelerating means for decelerating the moving speed of the focal point of the light beam; and jumping lead-in means for detecting that the light beam arrives a target information face by that the signal output from the focusing state detecting means reaches a predetermined level, thereby operating the focus control means.

[0027]

A fourth construction of the present invention is an

optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on a recording medium having tracks on which concave and convex signals corresponding to pit parts and mirror parts are recorded in advance; first signal detecting means for detecting a first signal which becomes large when the light beam focused by the focusing means deviates in the positive direction from the recording medium; second signal detecting means for detecting a second signal which becomes large when the light beam focused by the focusing means deviates in the negative direction from the recording medium; first and second peak hold means for peak-holding parts of the first and second signal detecting means corresponding to the mirror parts, respectively; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium in accordance with first and second peak hold signals; moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; and focus control means for driving the moving means according to the output signal from the focusing state detecting means so that the focus position of the light beam on the recording medium becomes approximately constant.

[0028]

A fifth construction of the present invention is an optical recording and reproduction apparatus comprising: focusing means

for focusing a light beam on a recording medium having plural layers of information faces; first moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium; second moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surface of the recording medium and the direction of tracks; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on the recording medium; track error detecting means for generating a signal corresponding to the positional relationship between the focal point of the light beam on the recording medium and a track; focus control means for driving the first moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; tracking control means for driving the second moving means in accordance with the output signal from the track error detecting means to control the focal point of the light beam on the recording medium so that it correctly scans the tracks; focus jumping means for making the focus control means go from the operating state to the non-operating state, and driving the moving means to move the focal point of the light beam from an information face to another information face of the recording medium; learning means for operating the focus control means and

the tracking control means in each information face of the recording medium at starting of the apparatus, and learning and selecting set values required in the focus control means and the tracking control means; and storage means for storing the set values; and the learning means being constructed so that it selects a set value for a target information face from the set values stored in the storage means, when the light beam is moved to the target information face by the focus jumping means after learning in each information face.

[0029]

A sixth construction of the present invention is an optical recording and reproduction apparatus comprising: focusing means for focusing a light beam on plural recording media having different base material thicknesses; first moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surfaces of the recording media; second moving means for moving the focal point of the light beam focused by the focusing means in a direction substantially perpendicular to the surfaces of the recording media and the direction of tracks; focusing state detecting means for generating a signal corresponding to the focusing state of the light beam on each of the recording media; track error detecting means for generating a signal corresponding to the positional relationship between the focal point of the light beam on the recording medium and a track; focus control

means for driving the first moving means in accordance with the output signal from the focusing state detecting means to control the light beam on the recording medium so that it enters a predetermined focusing state; tracking control means for driving the second moving means in accordance with the output signal from the track error detecting means to control the focal point of the light beam on the recording medium so that it correctly scans the tracks; light quantity signal measuring means for measuring the amplitude of a signal according to the quantity of reflected light from the recording medium every time the focal point of the light beam passes each information face when the moving means is driven at starting or resuming the apparatus such that the focusing means is made to approach the recording medium and then go away from the medium or it is made to go away from the recording medium and then approach the medium; recording medium judge means for judging the kind of the recording medium loaded in the apparatus in accordance with the signals from the light quantity signal measuring means or the focusing state detecting means; and a storage means for storing set values relating to the focus control means and the tracking control means, according to the signal from the recording medium judge means; wherein, if the focus control means or the tracking control means does not operate normally, the set values which are set according to the disk judge means and stored in the storage means, are changed to set values of another recording medium.

[0030]

[Embodiments of the Invention]

Embodiments of the present invention will be described by using figures 1 through 18. Figure 1 illustrates an optical recording and reproduction apparatus of the present invention, which is common to all the embodiments.

[0031]

In figure 1, the apparatus comprises a light source 108 such as a semiconductor laser, a coupling lens 109, a polarization beam splitter 110, a hologram element 106, and a focusing lens 105 (components of an optical system for irradiating a disk 101 as a recording medium with light beams 107a and 107b), and a disk motor 102 for rotating the disk 101 at a predetermined rotating speed. A light beam emitted from the light source 108 is collimated by the coupling lens 109. Then, the collimated light is reflected by the polarization beam splitter 110, passes through the hologram element 106, is split into two beams, and focused by the focusing lens 105, thereby forming light beam spots which form two focal points 107a and 107b.

[0032]

The respective light beam spots 107a and 107b irradiate the disk 101 which is rotated by the disk motor 102. These two light beams are properly used according to the base material thickness of the disk loaded. For example, when using a disk having a

thickness of 1.2 mm such as a CD, the light beam 107b is focused on the information face. On the other hand, when using a high-density disk having a substrate thickness of 0.6 mm such as a DVD, the light beam 107a is focused on the information face.

[0033]

Further, as a disk used in the recording and reproduction apparatus of the present invention, besides the conventional single-layer disk having one reproduction face such as a CD, there is a dual-layer disk in which two films are bonded like a sandwich by using an adhesive layer of 20~60 microns and having a semi-transparent film for one of information faces as shown in figure 6(a), or an N-layer disk (in the figure, N=4) in which recording and reproducing films each having a thickness of several microns are laminated as shown in figure 6(b).

[0034]

This recording and reproduction apparatus further includes a condenser lens 111 and a photodetector 113 divided into four parts, as elements for receiving a reflected light from the disk 101. The reflected light from the disk 7 travels through the focusing lens 105, the hologram element 106, and the polarization beam splitter 110, is input to the photodetector 113 through the condenser lens 111, and then input to a focus control unit and a tracking control unit which are composed of the DSP 129, the AD converters 123 and 124, the gain change circuits 121 and 122 etc.

[0035]

The tracking control unit comprises the photodetector 113 divided into four parts, preamplifiers 114a, 114b, 115a, and 115b, adders 116 and 117, comparators 118 and 119, a phase comparator 134, a differential amplifier 120, a gain change circuit 122, a DSP 129, an A/D converter 124, a driving circuit 130, and a tracking actuator 103. The light beam input to the photodetector 113 is converted to electric signals (current), and the electric signals are converted to voltage signals and amplified by the preamplifiers 114, 115b, 114a, and 115a, respectively. The amplified signals are added for each diagonal direction by the adders 116 and 117, binarized by the comparator 119 and 118, and phase-compared by the phase comparator 134. Then, high frequency components of the phase-compared signals are cut off, and the resultant signals are input to the differential amplifier 120. It is known that the output from the differential amplifier 120 shows the result of comparison of phases of data parts on the disk 101 of the light beam irradiating the photodetector 113, that is, it is a signal indicating an error of the light beam spot from the track on the disk 101. So, the output from the differential amplifier 120 is a track error signal (TE) according to the phase difference method, for controlling the light beam so that it correctly scans the tracks.

[0036]

The TE detection method is not restricted to the phase difference method of this embodiment, and any detection method,

such as a push-pull method or a three beam method, can be applied to the present invention.

[0037]

The TE is adjusted to a predetermined amplitude (gain) by the gain change circuit 122. Thereafter, it is converted to a digital value by the A/D converter 124, and input to the DSP 129.

[0038]

On the other hand, the focus servo unit comprises the photodetector 113 divided into four parts, the preamplifiers 114a, 114b, 115a, and 115b, the adders 116 and 117, a differential amplifier 133, a gain change circuit 121, an A/D converter 123, the DSP 129, a driving circuit 131, and a focus actuator 104.

[0039]

The output signals from the light responsive parts A-D of the photodetector 113 are subjected to current-to-voltage conversion and amplified by the preamplifiers 114a, 115b, 114b, and 115a, respectively. The amplified signals are added for each diagonal direction by the adders 116 and 117 and then input to the differential amplifier 133.

[0040]

It is known that the output from the differential amplifier 133 is a signal indicating a focus error of the light beam spot on the information face of the disk 101, of the light beam irradiating the photodetector 113, that is, the output from the differential amplifier 120 is a focus error signal (FE) according

to so-called astigmatic method, for controlling the light beam so that it is in a predetermined focused state on the information face of the disk 101.

[0041]

The FE detection method is not restricted to the astigmatic method, and any detection method, such as a knife edge method or an SSD method, can be applied to the present invention.

[0042]

The amplitude of the FE is adjusted to a predetermined amplitude (gain) by the gain change circuit 121, in accordance with the amount of light beam corresponding to the reflectivity or the like of the disk 101. Thereafter, the FE is converted to a digital value by the A/D converter 123 and input to the DSP 129.

[0043]

Figure 2 is a block diagram illustrating, in detail, the focus servo and focus lead-in section of the DSP 129. The DSP 129 constitutes a digital control system in it, and comprises a switch 201, a phase compensating filter 202, a gain change unit 203, a switch 204, an S signal detector 205, a level judge unit 206, a waveform generator 207, and a hold unit 208.

[0044]

The FE which is converted to a digital signal by the A/D converter 123 is input to the phase compensating filter 202 comprising an adder, a multiplier, and a delay unit, through the switch 201 which opens and closes a loop of the focus servo

system. The FE whose phase delay in the focus control system is compensated by the phase compensated filter is input to the switch 204 through the gain change unit 203 which sets the loop gain of the focus servo system. The switch 204 opens and closes the loop of the servo system. Further, when focus lead-in is performed, the switch 204 applies an UP/DOWN signal for detecting the information face of the disk 101 by making the focusing lens 105 come close to and go away from the disk 101, through the D/A converter 209 to the driving circuit 131 for driving the focus actuator 104. The FE signal which passes through the switch 204 during the focus control operation is converted to an analog signal by the D/A converter 209 and input to the driving circuit 131. In the driving circuit 131, the FE is subjected to appropriate current amplification and level change, whereby the focus actuator 104 is driven. In this way, the focus actuator 104 is driven so that the light beam on the disk 101 is always in the predetermined focused state.

[0045]

When performing focus lead-in, the waveform generator 207 outputs a chopping-wave-shaped UP/DOWN signal, turns on the B-C line of the switch 204, drives the focus actuator 104 through the D/A converter 209 and the driving circuit 131, and moves the focusing lens 105 up toward the disk 101 and then downward away from the disk 101.

[0046]

More specifically, with reference to figure 2, the FE after A/D conversion branches in the DSP 129 and realizes focus lead-in learning operation. That is, the disk 101 is rotated, the semiconductor laser 108 is made to emit light, and an UP/DOWN signal is output from the waveform generator 207, whereby the focusing lens 105 is moved up toward the disk 101 and then downward away from the disk 101. At this time, in the S signal detector 205, the FE which has branched after AD conversion is set as follows. The amplitude of an S signal which appears in the FE during the up and down movement of the focusing lens 105 is measured, and when the measured amplitude is smaller than a predetermined amplitude, the gain change circuit 122 is controlled to reduce the gain of the FE. When the amplitude is larger than the predetermined amplitude, the gain change circuit 122 is controlled to increase the gain. Therefore, it is possible to make the amplitude of the S signal constant by the output after the A/D converter 124. The FE whose S signal has the predetermined amplitude by the S signal detector 205 and the gain change circuit 122, is input to the level judge unit 206. The input FE is compared with a predetermined amplitude level (lead-in level) by the level judge unit and, after detection of the lead-in level, switch 201 is turned on and the A-C line of the switch 204 is turned on to close the focus servo loop, whereby the focus lead-in operation is achieved.

[0047]

(Embodiment 1)

A detailed description is given of a focus lead-in method in the optical recording and reproduction apparatus according to a first embodiment of the present invention. To simplify the description, a CD is employed as a disk having a 1.2 mm thick base material, and a DVD-ROM having a base material thickness of 0.6mm is employed as a thin base material disk.

[0048]

As described above, in the optical recording and reproduction apparatus of the present invention, in order to secure compatibility between a disk having a 1.2mm thick base material such as a CD, and a disk having a 0.6mm thick base material such as a DVD, the light beam is divided into two beams by using the hologram element 106 so that the two light beam spots are focused on the respective disks. Therefore, when the focusing lens 105, i.e., the respective light beam spots, are moved close to and away from the disk 101 during the lead-in operation, S signals are detected on the FE every time the two light beam spots passes through the information face of the disk. That is, S signals due to the light beam for the 1.2 mm thick CD and S signals due to the light beam for the 0.6 mm thick DVD appear as shown in figure 3.

[0049]

By the way, the light beam spot for the CD (CD beam) is focused in a position farther (upper) than the light beam spot

for the DVD (DVD beam). So, as shown in figure 3(a), the first S signal which appears when the focusing lens 105 is moved toward the disk 101 from its farthest position, shows that the CD beam is focused on the formation face. As shown in figure 3(b), the first S signal that appears when the focusing lens 105 is moved downward from the position nearest to the disk 101, shows that the DVD beam is focused on the information face.

[0050]

Therefore, when the CD is loaded in the apparatus, the lens is once moved away from a mechanical neutral point. When the CD beam spot is sufficiently distant from the disk, the lens is moved up toward the disk, and an S signal that appears first is detected, whereby the CD beam can be focused on the information face of the CD. On the other hand, when the DVD is loaded in the apparatus, the lens is once moved up toward the disk. When the DVD beam spot sufficiently goes through the disk, the lens is moved away from the disk, and an S signal that appears first is detected, whereby the DVD beam can be focused on the information face of the DVD.

[0051]

Actually, since both the CD and the DVD have a diameter of 120 mm, it is difficult to distinguish these disks. Therefore, as shown in figure 4, the focusing lens is once moved away from the initial position 0 to the point A and then moved up to the disk, and whether the disk is a CD or a DVD is decided according

to an S signal amplitude P_C that appears first in the FE at the point B or a signal amplitude that appears first in an AS (total light amount signal, i.e., the sum of signals from the adders 116 and 117). When the disk is a DVD, after the focusing lens reaches the point D nearest to the disk, the focusing lens is gradually moved away from the disk, and the information face of the DVD is detected by that an S signal Q_D that appears first reaches a predetermined level LVL1, i.e., point E, and focus lead-in is performed at this point E. When the disk is a CD, after the focusing lens reaches the point D nearest to the disk, the focusing lens is moved through the point E to the point F farthest from the disk and then moved upward from the point F, and the information face of the CD is detected by that an S signal R_C, which appears first reaches a predetermined level LVL2, point G, and focus lead-in is performed at this point G.

[0052]

In the above-described construction, high-speed and stable focus lead-in is realized for both the DVD having a 0.6mm thick base material and the CD having a 1.2mm base material.

[0053]

The specific procedure of the focus lead-in operation will be described by using figures 4(a), 4(b), and 5.

[0054]

Figure 5 is a flowchart showing the procedure of this focus lead-in. As shown in figure 5, when the power is applied to the

recording and reproduction apparatus, the motor 102 rotates, and when the disk 101 reaches a predetermined rotating speed, the semiconductor laser 108 as a light source emits light.

[0055]

Thereafter, in step S1, the waveform generator 207 generates a chopping wave signal which drives the lens up and down, and the focusing lens 105 is moved down to point A farthest from the disk by using the driving circuit 131 and the focus actuator 104 through the DA converter 209.

[0056]

When the focusing lens 105 reaches the farthest point A, the focusing lens 105 is moved up toward the disk 101, and an FE signal at this time is sampled in steps S2, S3 and S4. As shown in figure 4(b), when the focusing lens 105 gradually moves up, the focal point of the CD beam 107b, which is more distant from the lens than the focal point of the DVD beam 107a, reaches the information face of the disk at point B, and the S signal P_c due to the CD beam appears in the vicinity of the point B.

[0057]

The amplitude of the S signal P_c is measured in the following method. That is, the FE is continuously sampled, a MAX value or a MIN value is obtained while comparing the sampled values, and an amplitude is obtained from the MAX value or the MIN value.

[0058]

When measurement of the amplitude of the S signal P_c is completed, the focusing lens is moved closer to the disk 101 (step S5).

[0059]

When measurement of the amplitude of the S signal P_c is completed, lens UP is continued until reaching the point D nearest to the disk (step S6). Meanwhile, since the focal point of the lower DVD beam 107a also crosses the information face, the corresponding S signal P_D appears in the FE and so an amplitude of this S signal P_D is measured (steps S7 and S8). When the focusing lens reaches the nearest point D (steps S9 and S10), the measured values of the S signals P_c and P_D due to the CD beam and the DVD beam are compared to decide whether the disk loaded is a CD or a DVD (step S11).

[0060]

When the focusing lens 105 is moved away from the disk 101 after it has reached the nearest point D, the focal point of the lower DVD beam 107a crosses the information face, and an S signal corresponding to it appears in the FE. Next, the focal point of the upper CD beam 107b crosses the information face, and an S signal corresponding to it appears in the FE.

[0061]

Therefore, when the disk loaded is identified as a DVD, as shown in figure 4(a), it is detected that the S signal Q_D, which appears first when the focusing lens moves away from the point D,

reaches the predetermined lead-in level LVL1, and focus control is performed (steps S19, S20, S21, S22 and S23).

[0062]

On the other hand, when the disk loaded is identified as a CD, as shown in figure 4(b), the focusing lens 105 is moved from the nearest point D to the farthest point F, and S signals that appear during this movement are ignored (steps S12 and S13). Then, the focusing lens is again moved toward the disk from the farthest point F, and it is detected that the S signal R_c which appears first reaches the predetermined lead-in level LVL2, whereby focus control is performed (steps S14, S15, S16, S17 and S18).

[0063]

When the apparatus is constructed and functioned as described above, lead-in operation of focus control of a DVD or a CD is realized.

[0064]

(Embodiment 2)

Figure 6 shows a cross-sectional view of a dual-layer DVD in which 0.6 mm thick base material films are bonded to each other, and a cross-sectional view of a multiple-layer disk in which a plurality of thin signal films are laminated. Hereinafter, the procedure of a method for leading a focus in such a dual-layer or multiple-layer disk will be described as a second embodiment, taking a dual-layer disk as an example.

[0065]

Figure 7 is a waveform diagram illustrating an FE signal, a focus actuator driving signal, and the relative positions of a focusing lens and a disk, when the lens is moved close to and away from a dual-layer disk having two information faces, in which 0.6mm thick base material disks are bonded to each other. As shown in figure 7, two continuous S signals (double S signals, e.g., P1 and P2) are obtained on the FE signal which is obtained from the differential amplifier 133 and through the gain change circuit 121 and the AD converter 123. Learning is performed so that the amplitude of each S signal becomes constant, a predetermined level in the vicinity of the 0 cross as a focal point is detected, and the focus lead-in is performed.

[0066]

Figure 8 is a waveform diagram illustrating the FE in the practical focus lead-in operation and the UP/DOWN signal output from the waveform generator 207, i.e., the focus driving signal. In figure 8, the same alphabet as in figure 7 designates the corresponding position. Figure 9 is a flowchart of the focus lead-in learning procedure realized by the DSP 129.

[0067]

Like a single-layer disk, when further description is given by using figure 2, the FE after A/D conversion branches in the DSP 129 and realizes focus lead-in learning operation. That is, the disk 101 is rotated, the semiconductor laser 108 emits light,

and the waveform generator 207 outputs the UP/DOWN signal, whereby the focusing lens 105 is moved up toward the disk 101 and down away from the disk 101. At this time, in the S signal detector 205, the FE which has branched after AD conversion is set as follows. The amplitude of an S signal which appears in the FE during the up and down movement of the focusing lens is measured, and when the measured amplitude is smaller than a predetermined amplitude, the gain change circuit 122 is controlled to reduce the gain of the FE. When the amplitude is larger than the predetermined amplitude, the gain change circuit 122 is controlled to increase the gain. Therefore, it is possible to make the amplitude of the S signal constant by the output after the A/D converter 124. The FE whose S signal has the predetermined amplitude by the S signal detector 205 and the gain change circuit 122, is input to the level judge unit 206. The input FE is compared with a predetermined amplitude level (lead-in level) by the level judge unit and, after detection of the lead-in level, switch 201 is turned on and the A-C line of the switch 204 is turned on to close the focus servo loop, whereby the focus lead-in operation is achieved.

[0068]

The waveform generator 207 generates an accelerating pulse and a decelerating pulse when the light beam spot moves from the first layer to the second layer or from the second layer to the first layer in a dual-layer disk. This will be later described

in more detail for a third embodiment.

[0069]

The relationship between the FE and the UP/DOWN signal output from the waveform generator 207 at the time of focus lead-in is as shown in figure 7. Figure 9 is a flowchart illustrating the procedure of focus lead-in realized by the DSP 129 according to the relationship, and further description will be given using figure 9.

[0070]

When the power is applied to the recording and reproduction apparatus, the motor 102 rotates and, when the disk 101 reaches a predetermined rotating speed, the semiconductor laser 108 emits light, whereby focus lead-in operation starts.

[0071]

In figure 9, the waveform generator 207 generates a chopping wave signal that drives the lens 105 UP/DOWN in step S1, whereby the focusing lens 105 is moved up to the nearest point H shown in figures 7 and 8 by using the driving circuit 131 and the focus actuator 104 via the switch 204 and the DA converter 209. At this time, the focal point of the light beam 105a is positioned above the recording/reproduction face L1 of the second layer of the disk.

[0072]

When the focusing lens 105 reaches the nearest point H, the focusing lens 105 is moved down so that it goes away from disk

101, and an FE signal at this time is sampled, in steps S2 and S3. As shown in figure 7, when the focusing lens 105 gradually moves downward, the focal point of the light beam 107a which is near to the lens reaches the recording/reproduction face L1 of the second layer of the disk at the point I, and an S signal Q2 corresponding to the L1 face appears in the vicinity of the point I.

[0073]

There are various kinds of methods for measuring the amplitude of the S signal Q2. For example, there is easily realized a method in which the FE signal is continuously sampled, a MAX value or a MIN value is obtained by comparing the sampled values, and an amplitude is obtained from the MAX value or the MIN value. Further, in order to prevent the precision of the sampled FE signal from being degraded due to circuit noise or noise due to an address part preformatted on the disk or scratches on the disk, the sampled FE is filtered by a digital low-pass filter that is constituted by software processing of the DSP 129, and a MAX value or a MIN value is obtained from the FE signal which has been filtered by the digital filter, whereby the amplitude can be measured with high precision.

[0074]

When measurement of the amplitude of the S signal Q2 is completed, lens DOWN is continued to sample the FE (steps S5, S6, S7). Since the distance between the second layer L1 and the

first layer L0 is about 40 microns, after the light beam spot has passed through the point I of the L1, it reaches the point J of the L0 of the recording/reproduction face. In the vicinity of the J point, an S signal Q1 equivalent to the quantity of light at this point appears. In step 8, this S signal Q1 is measured in the same manner for the S signal Q2.

[0075]

When measurement of the amplitude of the S signal Q1 is completed, lens DOWN is continued to the farthest point E. During the lens DOWN, since the focal point of the upper light beam 107b crosses the recording/reproduction face, an S signal corresponding to it appears in the FE. When the surface deflection is significant, the light beams 107a and 107b detect the recording/reproduction face at almost the same time, and the two S signals interfere with each other to become deformed nonlinear S signals. However, this portion is ignored, and DOWN is continued until reaching the farthest point A (steps S10, S11).

[0076]

When reaching the farthest point A, the focusing lens 105 is again moved up from the point A toward the disk 101. Then, since the focal point of the upper light beam 107b crosses the recording/reproduction face, an S signal corresponding to it appears in the FE. When the surface deflection is significant, since the light beams 107a and 107b detect the recording/reproduction face at almost the same time, the two signals

interfere with each other to become deformed nonlinear S signals, and so it is difficult to accurately detect the information faces L0 and L1 with the light beam 107a. Therefore, during the lens UP, detection of S signals is not performed, and the focusing lens 105 is quickly moved up to the nearest point H (step S12). At this time, based on the amplitudes of the S signal Q2 of the second layer and the S signal Q1 of the first layer which have been measured during the previous lens DOWN, an appropriate focus gain is calculated for each layer, and the set value of the gain change circuit 122 is stored in a RAM (not shown in the figure) in the DSP 129. Further, an amplitude of the S signal at the changed gain value is calculated, and a value equal to 10~30% of the amplitude is set as a focus lead-in level. Thus calculated lead-in levels for the first layer L0 and the second layer L1 are also stored in the RAM in the DSP 129, like the S signal amplitude described above (steps S13, S14).

[0077]

Thereafter, a focus gain value and a lead-in level corresponding to the second layer L1 which is detected first by the light beam 105a when the focusing lens 105 is moved downward from the nearest point E, are set in the gain change unit 122 and the level judge unit 207, respectively (steps S15, S16). After the setting, the focusing lens 105 is moved downward to sample the FE, and the FE is compared with the set lead-in level. When the lead-in level is reached or exceeded, it is judged that the

lead-in level is detected. Then, the UP/DOWN signal is stopped to stop the downward movement of the lens, and the FCON, i.e., the switch 201 is turned on and the A-C line of the switch 204 is turned on to close the focus loop, whereby focus lead-in is achieved (steps S19, S20, S21). After focus lead-in is performed at the information face L1 at which the focal point of the light beam reaches first, the light beam is moved to a predetermined recording/reproduction face adjacent to the information face L1, wherein signal recording or reproduction is performed. The method of moving the light beam between the two layers will be described later for the third embodiment of the invention.

[0078]

Further, in this embodiment, after the focusing lens 105 is once moved up to the nearest point H from the mechanical neutral point, the focusing lens 105 is moved down to the farthest point A, and the amplitude of the S signal is measured. Then, learning of gain or the like is executed and, thereafter, the focusing lens 105 is again moved up to the nearest point H and then down from the nearest point H, and an S signal of the information face L1 which appears first is detected, whereby focus control is always led in the information face L1.

[0079]

Here, focusing lens 105 is once moved down to the farthest point A from the mechanical neutral point and then moved up from the point A to the point H, and an S signal which appears in the

FE during the lens UP is detected, whereby the gain is learned. Thereafter, an S signal of the information face L1 which appears first when the focusing lens 105 is moved down from the nearest point H is detected, whereby focus control is led in the information face L1, with the result that the time required for the focus lead-in is reduced.

[0080]

As described above, when a dual-layer or multiple-layer disk is loaded in the apparatus, the focus is always led in an information facet that is farthest from the focusing lens and, thereafter, the focus is moved to another information face as desired by using a focus jumping means according to a third embodiment of the invention which will be described later, whereby focus lead-in is performed stably , and moving to a desired information face is possible.

[0081]

By employing the second embodiment described above, in an optical recording and reproducing apparatus having two focuses corresponding to disks of different base material thicknesses, even when dual-layer or multiple-layer disks of different base material thicknesses are loaded in the apparatus, detection and measurement of S signals, gain change, and lead-in level learning can be performed accurately by using the upper and lower light beams corresponding to the respective disks, whereby the focus can be led in the recording and reproducing face which is

detected first with high reliability.

[0082]

Next, as a third embodiment of the invention, a focus jumping operation from an information face to another information face will be described by using figures 1, 2, and 10~12. Figure 10 is a block diagram illustrating, in detail, a section for tracking control in the DSP 129 shown in figure 1. Figure 11 is a diagram illustrating waveforms of an FE signal, a positive or negative pulse signal FEJMP pulse generated in the waveform generator and applied to the focus servo system, and a TE signal, when focus jumping is made from L0 to L1, and from L1 to L0. Figure 12 is a flowchart illustrating the procedure of focus jumping realized in the DSP 122.

[0083]

When focus jumping is made from the information face L0 to the information face L1 or from the information face L1 to the information face L2, this is realized by a focus jumping operation from an information face to another information face, which is constructed by software in the DSP 122 like the focus lead-in process described above, by applying a pulse signal FOJMP generated in the waveform generator 207 to the control system.

[0084]

For example, when focus jumping is made from L0 to L1, in step S1 of figure 12, the switch 301 shown in figure 10 is turned off to turn off tracking control (TROF), and in step S2, the B-C

line of the switch 204 shown in figure 2 is turned ON to hold a focus driving signal by the hold unit 208.

[0085]

Next, in step S3, an accelerating pulse A0 of a jumping pulse (FEJMP pulse) is generated in the waveform generator 207 shown in figure 2, and the accelerating pulse A0 is applied through the switch 204, the DA converter 209, and the driving circuit 131 to the focus actuator 104. The pulse width and the peak value of the accelerating pulse A0 are set according to the sensitivity of the focus actuator 104 and the surface deflection of the disk 101. When a predetermined pulse is applied to the focus servo system, the focusing lens 105 starts to move upward, i.e., toward the L1, and with this movement an S signals appears in the FE signal as shown in the left side of figure 11.

[0086]

When it is detected in step S4 that the S signal reaches a reference level 0, i.e., when the 0 cross of the FE (or an amplitude level in the vicinity of it), in steps S5 and S6 the gain set value of the gain change circuit 122 is changed to the state of the L1, and the focus lead-in level is set to the lead-in level of the L1 by the level judge unit 206. Thereby, the S signal and the lead-in level of the L1 are correctly detected. Further, in step S7, a decelerating pulse B0 generated in the waveform generator 207 like the accelerating pulse is applied. By the decelerating pulse B0, a brake is applied to the focusing

lens 105 which is moving toward the information face L1. So, when the FE signal reaches the lead-in level R0 of the L1, the moving speed of the focusing lens 105 is almost in the minimum state (closest to 0). At this time, the output of the decelerating pulse is stopped, and immediately the A-C line of the switch 204 is turned on to bring the focus control in the operating state, whereby the focus is stably led in, in the vicinity of the lead-in level point R0 (steps S8, S9). Thereafter, during the period of time to U0, it is confirmed that the focus is normally led in, by the TE signal or RF signal exceeding a predetermined value (steps S10, S11). Finally, in step S12, the switch 301 shown in figure 10 is turned on at the point U0 in figure 10 to bring tracking control in the operating state, and predetermined track and sector address are sought to end the processing.

[0087]

Since the gain of the FE at which the amplitude of the S signal in the L1 and the lead-in level at this time, which are set in steps S5 and S6, are learned during the focus lead-in operation described above and stored in the RAM of the DSP 122, sufficient correspondence is made even when the amplitude of the S signal of the FE or the like varies for each disk, apparatus, or head. Further, considering the lens speed at focus lead-in at starting and the lens speed at focus jumping, the lead-in level at focus jumping is calculated according to the S signal

amplitude and the lead-in level which are stored at starting, whereby more stable lead-in can be realized.

[0088]

For example, the amplitude of the S signal is stored in the RAM, in the form of a MAX value or a MIN value. Then, a level corresponding to a predetermined rate of the MAX value or the MIN value (preferably, 60-80%) is obtained as a comparator level. Then, the sampled FE signal is compared with the comparator level. The MAX value of the S signal is detected by that the FE signal becomes larger than the comparator level and, thereafter, smaller than the comparator level. Likewise, the MIN value of the S signal is detected by that the FE signal becomes smaller than the comparator level and, thereafter, larger than the comparator level. When the MAX value is detected in this way, the accelerating pulse is stopped and the decelerating pulse is output. When the MIN value is detected, the decelerating pulse is stopped and the accelerating pulse is output. In this way, the timing of acceleration and the timing of deceleration can be desirably changed by the comparator level. Especially when the timing is appropriately quickened within a range of the performance of the focus actuator 104, unwanted positional deviation due to surface deflection of the disk is significantly reduced, so that the focus jumping can be performed at high speed.

[0089]

Furthermore, when a signal obtained by dividing the FE by

the sum of outputs from the adders 116 and 117 shown in figure 1, i.e., by the total light amount signal AS, or a signal obtained by changing the set gain of the gain change circuit 121 according to the amplitude of the total light amount signal AS, is used in place of the FE to be sampled at the time of focus jumping, even if the reflectivity of the disk significantly varies between the information faces L1 and the information face L0 or between the inner circumference, the center, and the outer circumference, the lead-in level of the target information face can be accurately detected.

[0090]

When the focus moves from L1 to L0, the FE or FEJMP pulse becomes as shown in the right side of figure 10 and, also in this case, focus jumping can be realized by similar procedure and steps.

[0091]

In the above description, jumping is performed while holding the control signal input to the D/A converter 209 shown in figure 2, i.e., the FE driving signal. However, when surface deflection of the disk is considerable, the FE signal input to the switch 201 shown in figure 2 is filtered by a high frequency cut-off filter to eliminate noise component, and this signal is held during the jumping and then sent through the D/A 209 to the driving circuit 131. In this case, unstable factors caused by positional error due to the surface deflection are absorbed.

[0092]

By the way, as described above, the peak values of the accelerating pulse and the decelerating pulse are set according to the sensitivity of the focus actuator 104 and the stability of focus jumping with regard to surface deflection or shock from the outside. Especially when stability and high-speed ability are considered, the pulse width is approximately set at acceleration A0 : deceleration B0 = 2:1 while the pulse peak value is set at acceleration A0 : deceleration B0 = 1:2 so that the energy ratios (ratios of integral values) become approximately equal.

[0093]

Further, since the apparatus is usually set horizontally, when the accelerating direction of the focusing lens 105 is from the lower side to the upper side, the accelerating speed becomes +1G (G: gravitational acceleration), and when it is from the upper side to the lower side, the accelerating speed becomes -1G. The accelerating pulse and the decelerating pulse of the FOJMP pulse are set as follows. When the lens moves from L0 to L1, the peak value of the accelerating pulse A0 is set higher than that of the decelerating pulse B0, and when the lens moves from L1 to L0, the peak value of the decelerating pulse B0 is set higher than that of the accelerating pulse A0. The difference is about 2G. Thereby, stability can be assured in each setting direction.

[0094]

When the apparatus can be set horizontally and vertically,

the energy of the accelerating pulse is set a little larger than the energy of the decelerating pulse in the state where the apparatus is set horizontally, and as shown in figure 11 the lead-in level is set at a position where the light beam spot goes slightly beyond the target information face, whereby focus lead-in is always performed at a regular spot position which is slightly farther than the focus control position. Therefore, the difference in speed due to the difference in setting direction is absorbed, resulting in stable lead-in in both the cases of L1→L0 and L0→L1. Further, the DC components of the driving current for the focus actuator after FCON, i.e., the DC values of the input part of the DA converter 204, are detected and, according to the difference, it is decided whether the apparatus is set horizontally or vertically. According to the result of the decision, the accelerating pulse and the decelerating pulse are changed to the optimum values in the respective setting states. Thereby, even when the surface deflection of the disk is considerable or the focus actuator sensitivity or the like is not enough, focus stable jumping can be realized.

[0095]

In the above-mentioned lead-in method of the second embodiment, when the apparatus is started or resumed, focus lead-in is performed first on the second layer L1 of the dual-layer disk, that is, the information face farthest from the light beam emission side. So, when this layer is regarded as an initial

reference, the first focus jumping direction at starting of the apparatus is decided. More specifically, the information face in which the focus is first led in and then moved by the first focus jumping is always the adjacent information face in the direction toward the first L0 layer of the dual-layer disk, i.e., toward the light beam emission side. However, because of shock or the like from the outside, if the information face where the focus is first led in is not a correctly detected face or if the focus which has once been led in the target information face is undesirably jumped to another information face, since there is no more information face in the predetermined focus jumping direction in case of the dual-layer disk, focus control ends in a failure. In this case, however, the focus can be returned to the target information face by resuming the apparatus. In the case of a multiple-layer disk, the focus can be moved in both directions by focus jumping thought it depends on the position of the information face where the focus is led in. After the focus jumping, tracking is led in, and the focus is moved to a track of address information or predetermined information to read information written on the track, whereby it can be confirmed that the present position is incorrect. Therefore, by performing resuming or correction jumping with the address information, the focus can be returned to a predetermined information face.

[0096]

Furthermore, by storing the number of the information face

which is now subjected to focus control in the state where the address can be read, even if the focus control fails or the focus is led in another information face due to vibration or shock, the focus can be returned to the information face which has been under reproduction (or recording) according to the stored address.

[0097]

While in this embodiment a dual-layer disk having information faces L0 and L1 is described as an example, this embodiment can be adapted to a multiple-layer disk as shown in figure 6(b) by setting an information face farthest from the lens as an information face in which the focus is led first and, thereafter, moving the focus to desired information faces by focus jumping.

[0098]

A description is given of an optical recording and reproduction apparatus according to a fourth embodiment of the present invention.

[0099]

This apparatus cancels defocus during seeking to realize stable seeking, and is described by using figures 1, 13, 14, 15 and 16. Figure 13 is a block diagram illustrating a part of the apparatus for subjecting an FE signal to peak hold processing to realize focus control in the DSP 122. Figure 14 is a cross-sectional view illustrating the positional relationship between the focusing lens 105, the light beam 107a, and the disk 101, for

explaining the seeking process. Figure 15 is a diagram illustrating waveforms of F+ and F- signals before and after peak hold, respectively, and an FEENV signal which is a difference signal of F+ and F-, and an FE signal, when seeking is executed in the arrow direction A. Figure 16 is a block diagram illustrating the FE detecting part using the astigmatic method shown in figure 1 for explaining this embodiment.

[0100]

The modulation signal levels of track cross of F+ and F- vary due to errors in adjusting the optical elements such as the photodetector 113. Therefore, as shown in figure 15, the FE which is a difference signal of F+ and F- is adversely affected by the track cross according to the variation, resulting in defocusing. So, disturbance caused by the track cross is mixed during seeking, and thereby defocusing occurs to reduce the amplitude of the TE or degrade the S/N ratio. As the result, counting of the TE for detecting the position of the light beam in the track direction becomes impossible.

[0101]

Further, when the quantity of defocus increases, focus skipping occurs, and the focus cannot easily move to a target track.

[0102]

In figure 1, the F+ and F- signals which are obtained from the photodetector 113 through the preamplifiers 114 and 115, are

subjected to peak hold by the peak hold circuits 125a and 125b, that is, upper side peaks (peaks on the mirror side of the disk 101) of these signals are held, thereby generating signals F+PH and F-PH which are not adversely affected by track cross during seeking, as shown in figure 14. A difference of these two signals is obtained by the differential amplifier 126 to obtain an FEENV signal shown in figure 15.

[0103]

This FEENV signal is input to the gain change unit 127, wherein an optimum gain is set, and the amplitude is changed to a predetermined one. Then, the FEENV signal is sent through the A/D converter 128 to the DSP 129. Although focus control, focus lead-in, and focus jumping, which have conventionally been performed by using the FE, can be realized by using the input FEENV signal in like manner as mentioned above, if influence of track cross which appears in the FE is significantly large and sufficient response is needed at the time of focus jumping, a switch 401 by software processing is provided after the AD converter 124 and 128 as shown in figure 4. Only when seeking is performed, the B-C line of the switch 401 is turned on so that the FEENV is input, while usually focus control is performed by the FE obtained by the conventional astigmatic method.

[0104]

Although in this embodiment the astigmatic method is employed as an FE detection method, other detection methods may

be employed. However, since there is a tendency for the track cross to increase its influence, the effect of the FE detection using the astigmatic method is significant.

[0105]

(Embodiment 5)

A description is given of the procedure of activating a multiple-layer disk according to a fifth embodiment of the invention, taking a dual-layer disk as an example.

[0106]

A description is given of the activation procedure in the case where a dual-layer disk is loaded in the recording and reproduction apparatus to be reproduced by the lower side light beam 107a, with reference to figure 16. Figure 16 is a flowchart showing the procedure from activation of the disk motor to the state where reproduction is possible (stand-by state).

[0107]

When the power is applied to the apparatus and the dual-layer disk is loaded, the disk motor 102 is rotated at a predetermined rotating speed in step S1 (DMON). Next, in step S2, the semiconductor laser 108 is made to emit light (LDON), and the focus is led in the second layer L1 of the dual-layer disk which is detected first by the lower light beam 107a. In the state where the focus is so led in, MAX and MIN points of a sine wave shaped track cross signal which appears in the TE due to eccentricity is detected to obtain tracking offset (asymmetry),

and a correction value TOF1 is calculated to be stored.

[0108]

Next, in the case of phase difference tracking as described for the first embodiment, current is flowed in the tracking actuator, and a predetermined quantity of lens shift is made in positive and negative directions, and an optimum delay TEPH1 of each input to the phase comparator 134 shown in figure 1 is obtained so that the quantity of the TE signal is not degraded and the symmetry is not deformed (steps S3, S4, S5).

[0109]

After storing these values, the switch 304 shown in figure 3 is turned on with the TEF1 as a reference to turn on tracking control (step S6).

[0110]

After turning on tracking control, for example, the TE after the switch 301 is captured in a predetermined cycle (for example, 1 rotation 16 points) based on an FG pulse from the FG generator 132 mounted on the motor 102, and the average of N rotations is obtained to be stored in the eccentricity memory 306 constituted by the RAM in the DSP 129. After the storage, the TM1 stored in the eccentricity memory 306 is successively output at timing based on the FG to be added to the tracking servo system in the composition circuit 304, whereby feed-forward compensation is performed (step S7). Next, the jitter or amplitude of the RF signal is measured in the DSP 122 (input line

of the RF or jitter signal is not shown), and a focus offset is calculated such that the jitter becomes approximately minimum or the amplitude becomes approximately maximum, to be stored in the RAM (step S8). Further, disturbance is given to the focus servo system and the tracking servo system in the DSP 129 by software processing, and the loop transfer function signal is detected. By obtaining the transfer function, the focus gain correction value FOG1 and the tracking gain correction value TRG1 are calculated to be set and stored in the RAM (step S9). After calculation and storage of the learned values of the servo systems at the second layer L1, the focus is moved to the first layer L0 by the above-mentioned focus jumping FOJMP (step S10). Thereafter, in the state where tracking control is off (step S12), a TE offset TOF0 at the L0 is obtained to be set. Next, current is flowed in the tracking actuator, and a predetermined quantity of lens shift is made in positive and negative directions, and an optimum delay TEPH0 of each input to the phase comparator 134 shown in figure 1 is obtained so that the quantity of the TE signal is not degraded and the symmetry is not deformed (step 13).

[0111]

After storing these values, as described for the second layer L1, tracking control is turned on with the TE offset TOF0 as a reference (step S14), and an eccentricity correction value TM0 is obtained based on the FG pulse from the disk motor 102 and the TE. Thereafter, like the case of L1, FO offset FO0, gain

FOG0, and TRG0 are obtained to be stored in the RAM as values of L0 (steps S15, S16, S17).

[0112]

After calculating the learned values of L0 and L1 as described above, a predetermined track of a target layer is detected as requested by the system (step S18). When the focus is moved from layer to layer by focus jumping, the target layer, L0 or L1, is decided according to the information about which information face is the target face, and the values stored in the RAMs adapted to the respective information faces are set in predetermined registers of the focus servo system and the tracking servo system immediately before or after focus jumping or after end of the accelerating pulse of focus jumping, whereby stable focusing and tracking performances are obtained in any layer (steps S19, S20, S21).

[0113]

While in this fifth embodiment a dual-layer DVD is described, this embodiment is easily applied to a disk having three or more information faces by providing the DSP with RAMs for storing the learned values of the respective layers.

[0114]

(Embodiment 6)

A description will be given of a sixth embodiment of the present invention. As already described for the first embodiment, since both a CD and a DVD have a diameter of 120 mm, it is

difficult to distinguish these disks. Therefore, as shown in figure 4, the focusing lens is once moved away from the disk and then moved up to the disk, and it is decided as to whether the disk is a CD or a DVD according to an S signal amplitude that appears first in the FE or a signal amplitude that appears first in the AS (total light amount signal, i.e., the sum of signals from the adders 116 and 117). When the disk is a DVD, after the focusing lens reaches the point nearest to the disk, the focusing lens is gradually moved away from the disk, and the information face of the DVD is detected by that an S signal that appears first reaches a predetermined level, whereby focus lead-in is performed. When the disk is a CD, after the focusing lens reaches the nearest point, the focusing lens is moved to the point farthest from the disk and then moved upward from that point, and the information face of the CD is detected by that an S signal which appears first reaches a predetermined level, whereby focus lead-in is performed. However, due to variations of CD or DVD disks or variations of optical elements such as the hologram lens 106, the focusing lens 105 and the like, a CD loaded on the apparatus is sometimes misidentified as a DVD or, inversely, a DVD loaded on the apparatus is sometimes misidentified as a CD.

[0115]

In this case, even if focus control lead-in is retried several times, it cannot be achieved and the apparatus cannot be

started. So, when focus lead-in cannot be performed after the several times of retries, the RAM setting relating to the control system in the DSP 129 is changed from a CD to a DVD, or from a DVD to a CD. Further, in the case of a dual-layer DVD, as shown in figure 17, the RAM setting is changed as follows: CD → DVD's first layer → DVD's second layer; DVD's first layer → DVD's second layer → CD; DVD's second layer → CD → DVD's first layer. Thereby, the apparatus can be started even when the disks and the optical systems vary significantly. When focus lead-in cannot be performed in spite of setting all the disks, "error" is returned to the host since there is some failure or defect.

[0116]

Further, when the focus is accidentally led in the information face of the CD under the setting of the DVD, resetting due to retry over is performed similarly in the tracking control lead-in process. Thereby, the apparatus can be prevented from starting under wrong setting, and considerable increase in the starting time of a disk having large variation can be suppressed.

[0117]

The aforementioned embodiments of the present invention can be applied to all of multiple-layer disks for recording and reproduction, multiple-layer disks for reproduction only in which signals are recorded in advance, and apparatuses capable of recording or reproducing these disks.

[0118]

As is evident from the above description, an optical recording and reproduction apparatus according to the present invention has the following effects. 1) Focus control can be stably led in disks having different base material thicknesses such as a DVD and a CD. 2) The focus can be stably led in a dual-layer disk or a multiple-layer disk. 3) The focus can be moved rapidly and accurately to a desired information face in a dual-layer disk or a multiple-layer disk. 4) Since a peak of a focus signal is held to generate a focus error signal, defocus due to track cross during seeking is reduced, resulting in stable seeking. 5) A correction quantity of a phase difference TE of each control system, an offset, and correction values of a gain, eccentricity and the like are learned in each information face, and the correction values are calculated, and the correction values are changed to those adapted to an information face to which the focus is moved, whereby stable focusing and tracking performances are realized in any information face. 6) Even when the apparatus fails discrimination of disks such as a CD or a DVD, it is possible to start the apparatus by automatically changing setting. Therefore, a highly reliable apparatus adapted to mass storage multiple-layer disks can be provided.

[Brief Description of the Drawings]

[Figure 1]

A block diagram of an optical recording and reproduction

apparatus as an embodiment of the present invention.

[Figure 2]

A block diagram illustrating, in detail, a part of figure 1 relating to focus control and focus lead-in.

[Figure 3]

Waveform diagrams illustrating the relationships amongst a disk, an UP/DOWN signal, and an FE, in a CD and a DVD having different base material thicknesses, respectively.

[Figure 4]

Waveform diagrams illustrating an FE, an UP/DOWN signal, and an AS, of a CD and a DVD having different base material thicknesses, at the time of focus lead-in.

[Figure 5]

A flowchart of a focus lead-in process for explaining the first embodiment.

[Figure 6]

Diagrams illustrating cross-sectional views of a dual-layer disk and a multiple-layer disk used in the present invention.

[Figure 7]

A waveform diagram illustrating a lens driving signal and an FE for explaining a focus control lead-in operation according to the second embodiment, and a diagram illustrating the positions of a focusing lens in different stages.

[Figure 8]

A waveform diagram illustrating a lens driving signal, an

FE, and an RF signal, for explaining the focus control lead-in operation according to the second embodiment.

[Figure 9]

A flowchart illustrating the flow of the lead-in operation according to the second embodiment.

[Figure 10]

A block diagram illustrating, in detail, a part for tracking control and especially eccentricity correction, for explaining the third embodiment of the present invention.

[Figure 11]

A waveform diagram illustrating an FE, a lens driving signal, and a TE at the time of focus jumping which is a jumping operation of focus control according to the third embodiment.

[Figure 12]

A flowchart illustrating the jumping operation of focus control according to the third embodiment.

[Figure 13]

A block diagram illustrating, in detail, a part for focus control peak hold and its control, for explaining the fourth embodiment.

[Figure 14]

A diagram for explaining seeking on a dual-layer disk according to the fourth embodiment.

[Figure 15]

A waveform diagram illustrating F+ and F- during seeking,

F+PH and F-PH obtained by peak hold of these signals, and FE and FEENV which are difference signals of these signals.

[Figure 16]

A block diagram illustrating a circuit block when detecting an FE by astigmatic method.

[Figure 17]

A flowchart illustrating the flow of process for loading and activating a dual-layer disk, according to a fifth embodiment.

[Figure 18]

A flowchart illustrating the flow of recovery process when the apparatus fails disk discrimination, for explaining the sixth embodiment.

[Figure 19]

A block diagram illustrating the structure of the conventional focus control apparatus.

[Figure 20]

A waveform diagram for explaining the conventional focus control lead-in operation.

[Figure 21]

A waveform diagram for explaining the conventional focus lead-in operation.

[Figure 22]

A flowchart illustrating the flow of the conventional focus control lead-in operation.

[Description of Reference Numerals]

6 ... disk motor

7 ... disk

8 ... light beam

12 ... photodetector

14 ... differential amplifier

17 ... gain change circuit

19 ... linear motor

20 ... microprocessor

21 ... core

22 ... port

23 ... phase compensation circuit

24 ... S signal detector

25 ... UP/DOWN controller

26 ... motor controller

27 ... laser controller

33 ... switch

34 ... linear motor control circuit

35 ... driving circuit

36 ... focus actuator

37 ... motor control circuit

38 ... laser driving circuit

101 ... disk

102 ... disk motor

103 ... tracking actuator

104 ... focus actuator

105 ... focusing lens

106 ... hologram lens

107 ... focal point

108 ... semiconductor laser

109 ... coupling lens

110 ... polarization beam splitter

111 ... condenser lens

112 ... division mirror

113 ... photodetector

114 ... preamplifier

115 ... preamplifier

116 ... adder

117 ... adder

118 ... comparator

119 ... comparator

120 ... differential amplifier

121 ... gain change unit

122 ... gain change unit

123 ... AD converter

124 ... AD converter

125 ... peak hold circuit

126 ... differential amplifier

127 ... gain change unit

128 ... AD converter

129 ... DSP

130 ... driving circuit

131 ... driving circuit

132 ... FG generator

133 ... differential amplifier

134 ... phase comparator

201 ... switch

202 ... phase compensation filter

203 ... gain change unit

204 ... switch

205 ... S signal detector

206 ... level judge unit

207 ... waveform generator

208 ... HOLD unit

209 ... DA converter

301 ... switch

302 ... phase compensation filter

303 ... gain change unit

304 ... composition circuit

305 ... switch

306 ... eccentricity memory

307 ... JMP pulse generator

308 ... HOLD unit

401 ... switch

[Name of Document] Abstract

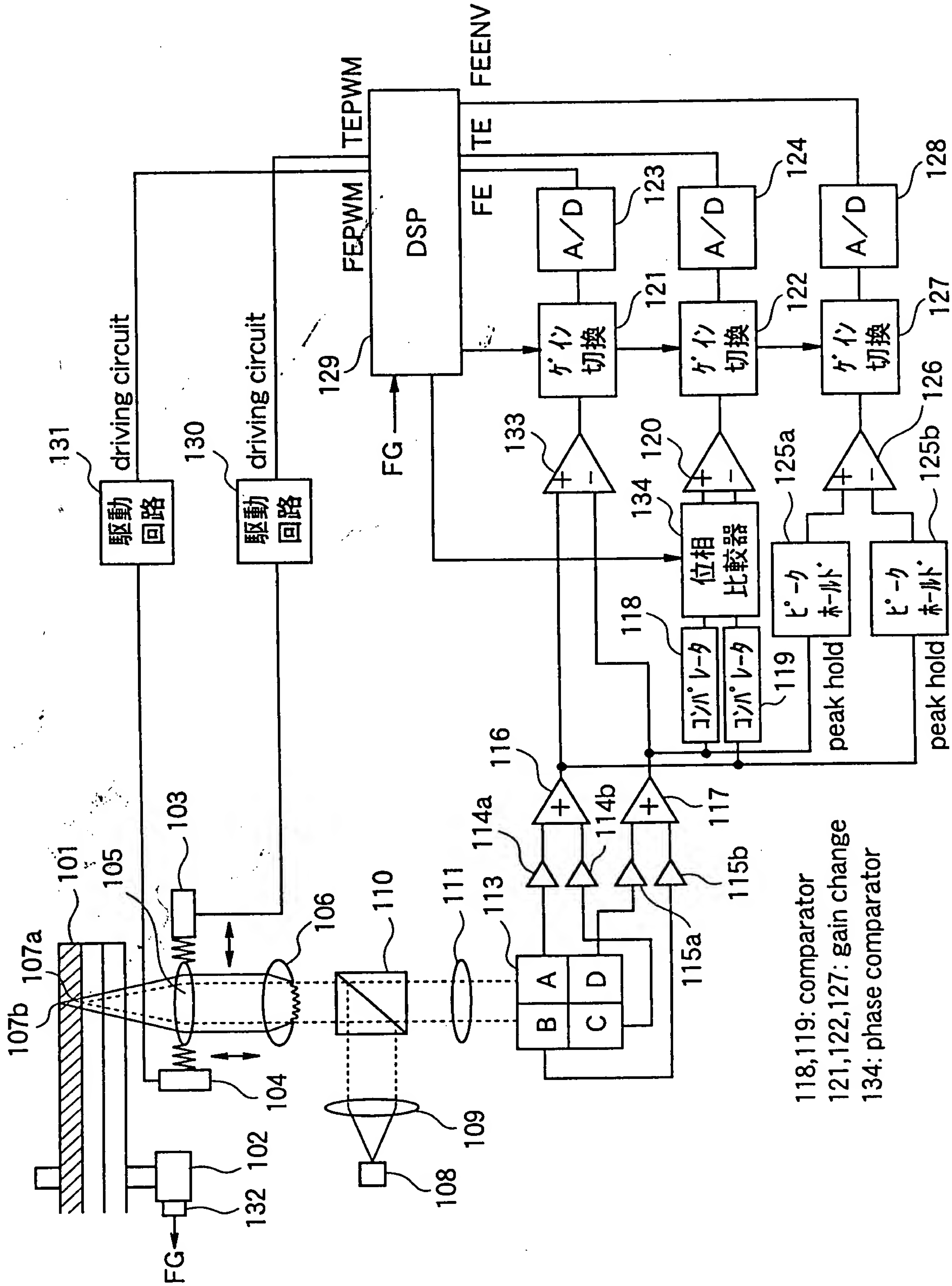
[Summary]

[Object] To realize high-speed and stable focus control of a head having two focuses or a disk having plural information faces.

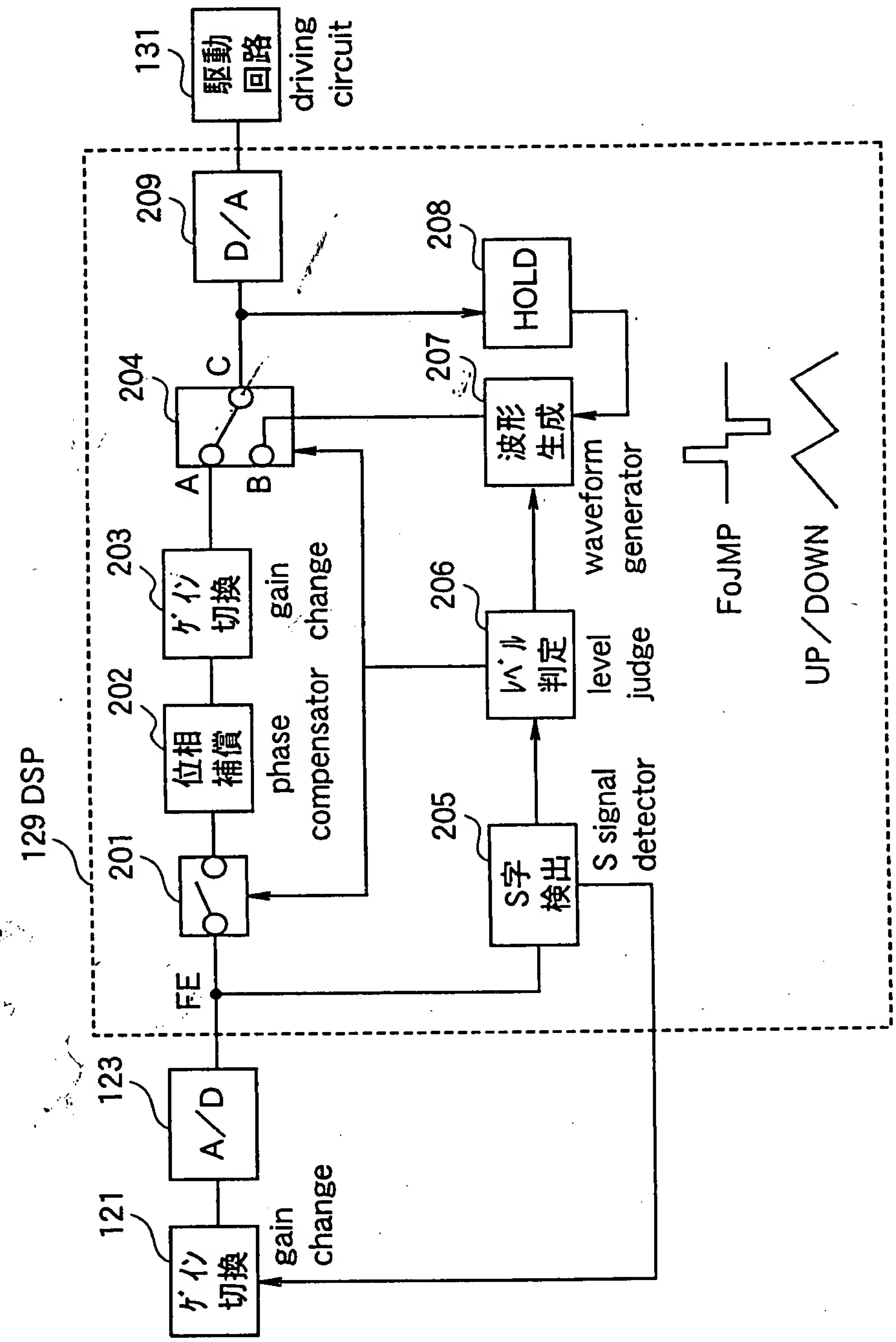
[Solution] When starting or resuming the apparatus, a focusing lens is driven toward a disk and then away from the disk, or it is driven away from the disk and then toward the disk. Meanwhile, the amplitude of an S signal which appears on an FE signal every time the focus of a light beam passes each information face of the disk, and the gain of a focus detection system is changed so that the amplitude becomes a predetermined amplitude, thereby setting an optimum lead-in level. Thereafter, when the lens positioned at the uppermost point is driven away from the disk (CD) or it is driven toward the disk from the lowermost point (DVD), focus control is operated at an information face at which the focus of the light beam arrives first, thereby completing the lead-in operation. Thereafter, focus control is once made inoperable, and the focusing lens is accelerated or decelerated in accordance with the level of the FE signal and the lead-in level set at each information face to move the lens to another information face.

[Selected Figure] Figure 1

Name of Document
【書類名】 図 面 Drawing
【図1】 Figure 1



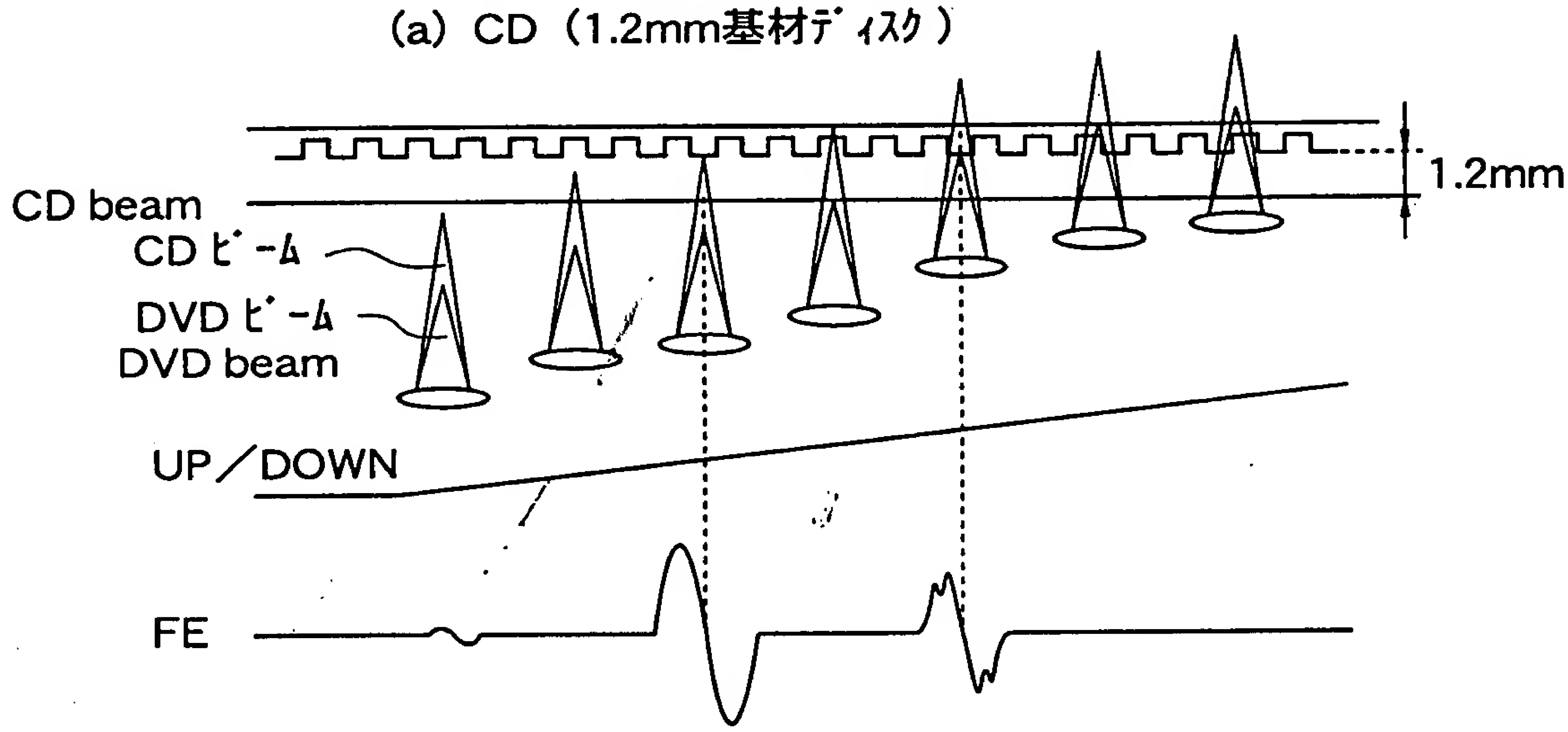
【図2】 Figure 2



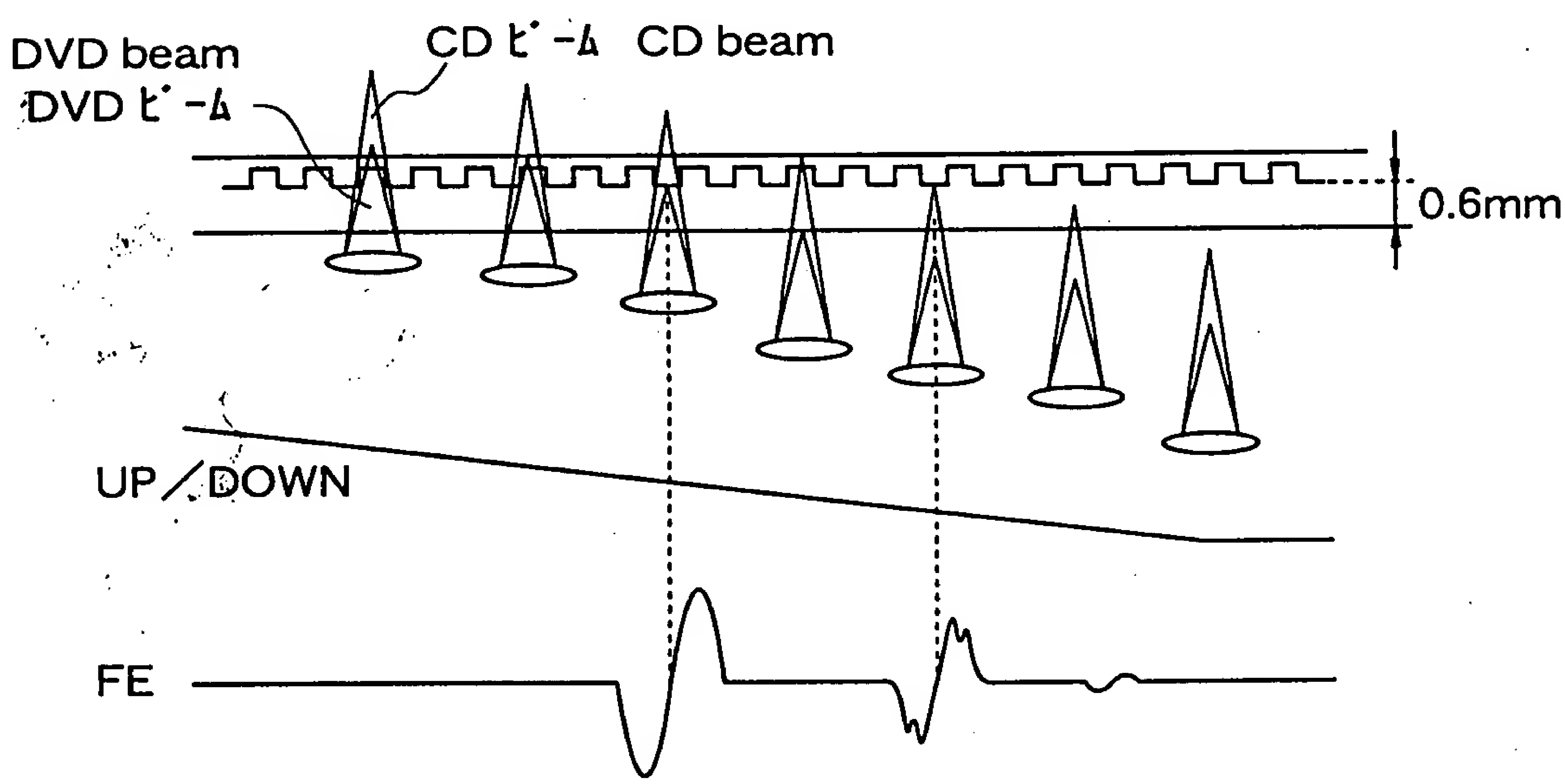
131
駆動回路
driving circuit
209
D/A
208
HOLD
207
波形生成
waveform generator
204
C
A
B
203
ゲイン切換
gain change
202
位相補償
phase compensator
206
レベル判定
level judge
205
S字検出
S signal detector
201
129 DSP
FE
123
A/D
121
ゲイン切換
gain change
FoJMP
UP/DOWN

【図3】 Figure 3

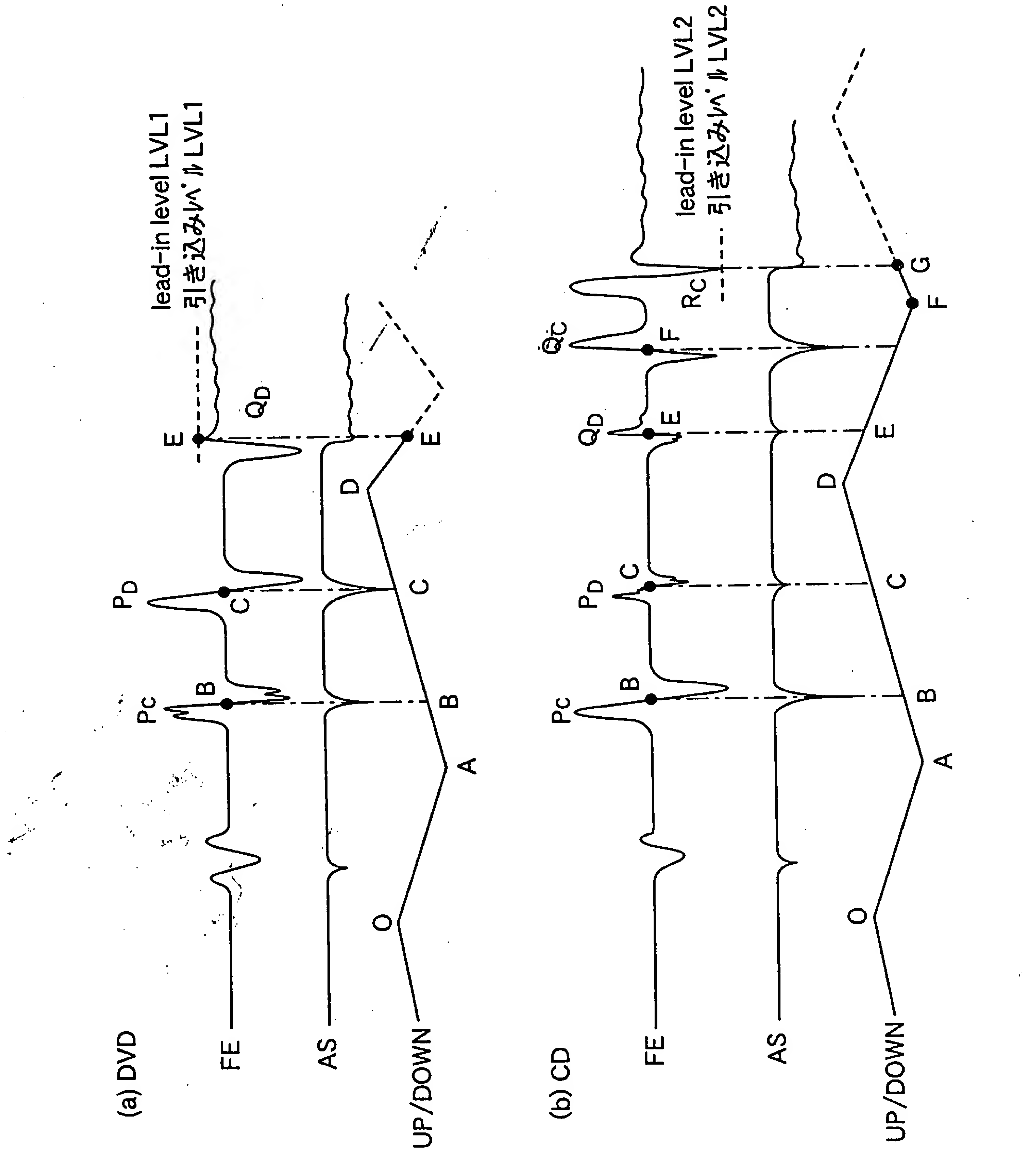
CD（1.2mm thick base disk ）
(a) CD（1.2mm基材ﾃﾞｨｽｸ）



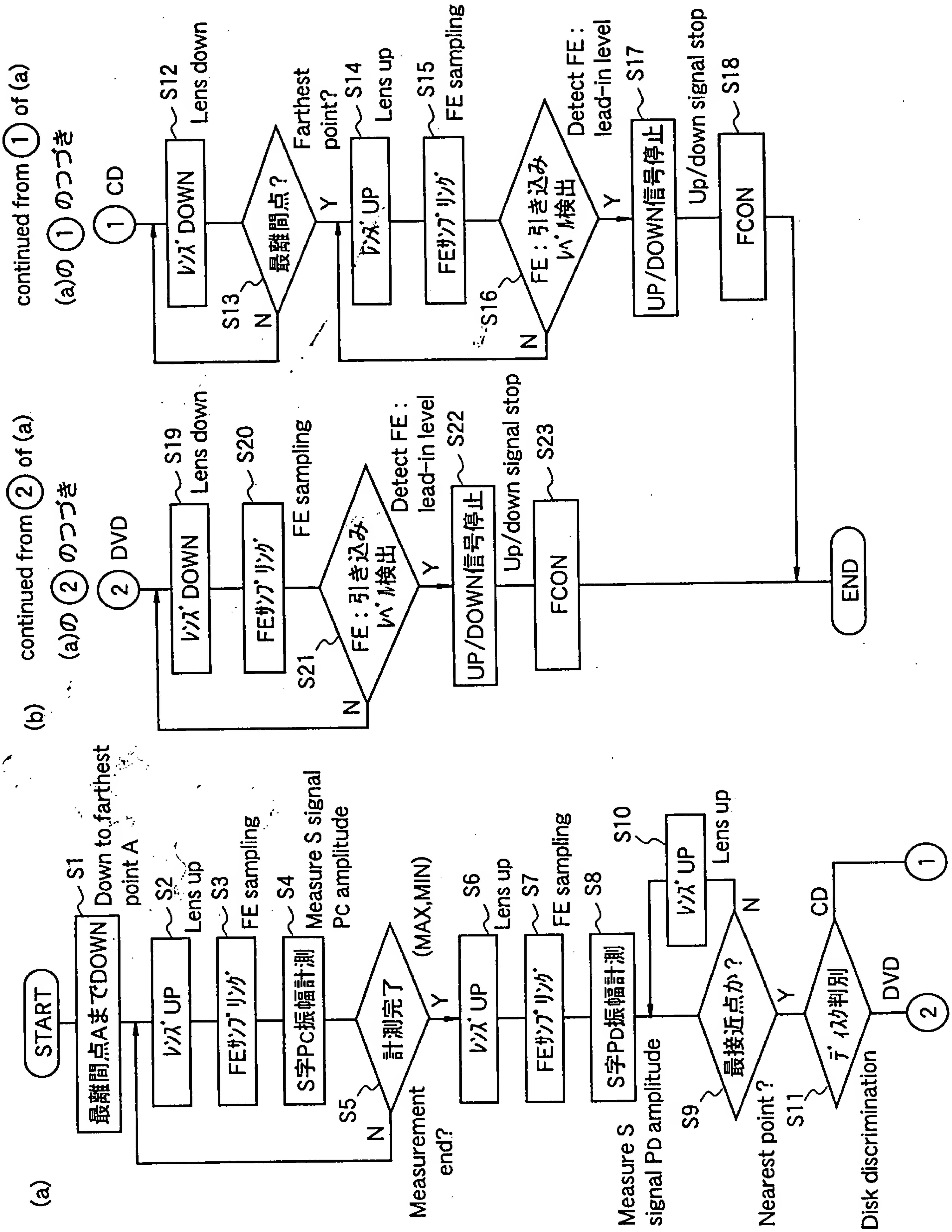
DVD（0.6mm thick base disk）
(b) DVD（0.6mm基材ﾃﾞｨｽｸ）



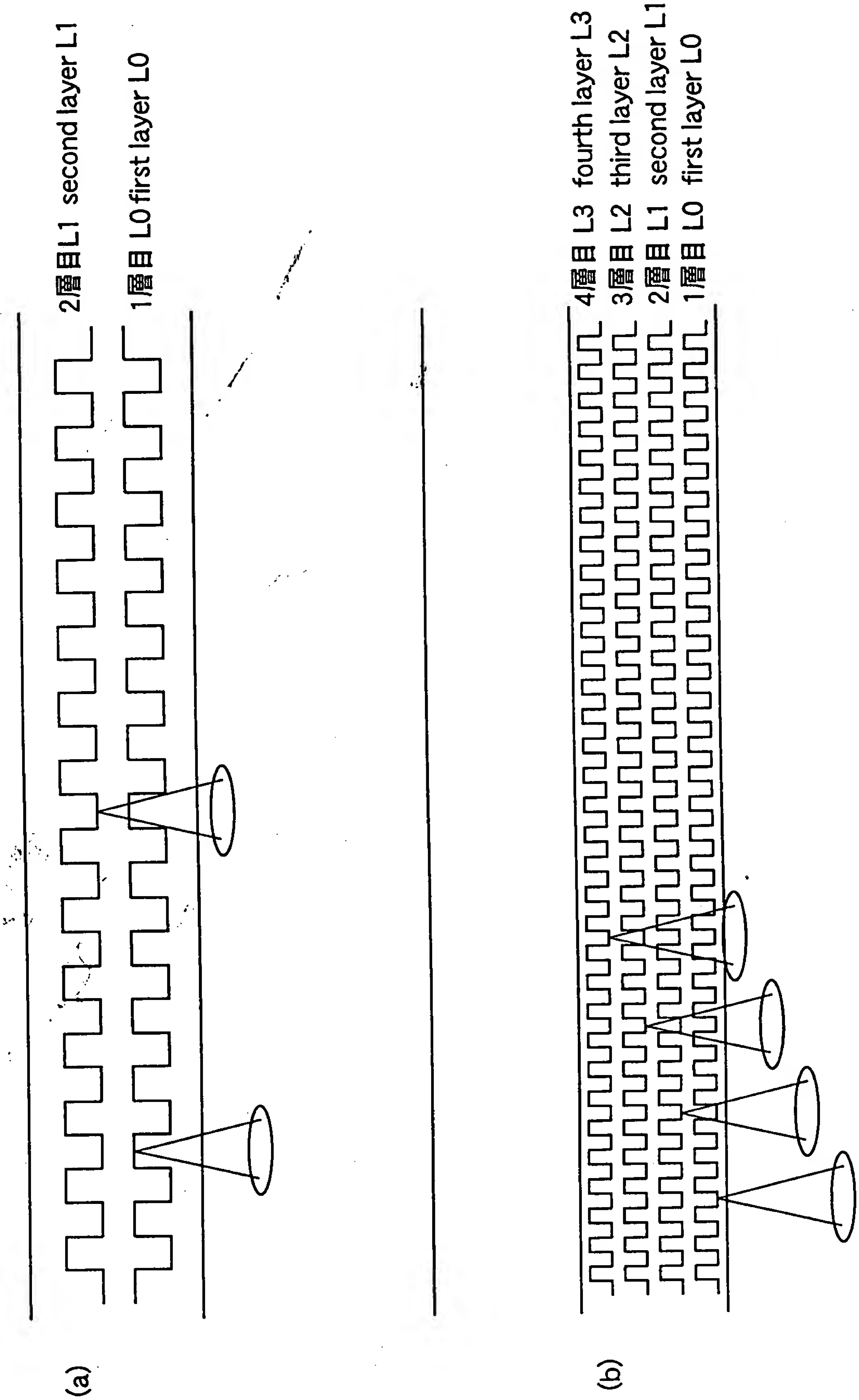
【図4】 Figure 4


(a) DVD
FE
AS
UP/DOWN
lead−in level LVL1
引き込みﾚﾍﾞﾙ LVL1
O
A
B
C
D
E
Pc
P_D
Q_D
(b) CD
lead−in level LVL2
引き込みﾚﾍﾞﾙ LVL2
Q_C
R_C
F
G

【図5】 Figure 5

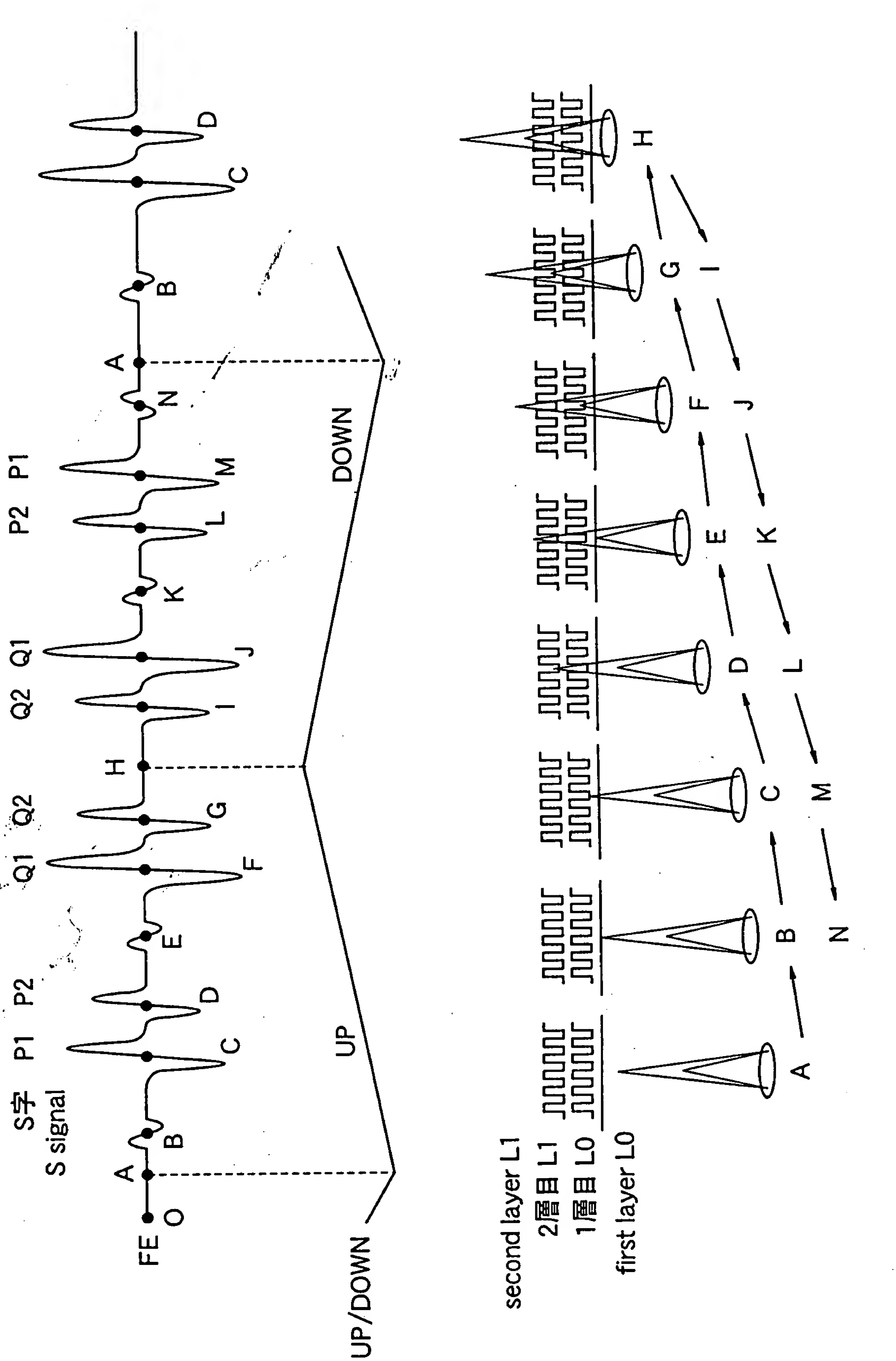

(a)
START
S1
最離間点AまでDOWN
Down to farthest point A
S2
ﾚﾝｽﾞUP
Lens up
S3
FEｻﾝﾌﾟﾘﾝｸﾞ
FE sampling
S4
S字PC振幅計測
Measure S signal PC amplitude
S5
計測完了
Measurement end?
(MAX,MIN)
Y
N
S6
ﾚﾝｽﾞUP
Lens up
S7
FEｻﾝﾌﾟﾘﾝｸﾞ
FE sampling
S8
S字PD振幅計測
Measure S signal PD amplitude
S9
最接近点か？
Nearest point ?
Y
N
S10
ﾚﾝｽﾞUP
Lens up
S11
ﾃﾞｨｽｸ判別
Disk discrimination
CD
DVD
1
2
(b)
continued from 2 of (a)
(a)の 2 のつづき
2 DVD
S19
ﾚﾝｽﾞDOWN
Lens down
S20
FEｻﾝﾌﾟﾘﾝｸﾞ
FE sampling
S21
FE：引き込みﾚﾍﾞﾙ検出
Detect FE : lead-in level
Y
N
S22
UP/DOWN信号停止
Up/down signal stop
S23
FCON
END
continued from 1 of (a)
(a)の 1 のつづき
1 CD
S12
ﾚﾝｽﾞDOWN
Lens down
S13
最離間点？
Farthest point?
Y
N
S14
ﾚﾝｽﾞUP
Lens up
S15
FEｻﾝﾌﾟﾘﾝｸﾞ
FE sampling
S16
FE：引き込みﾚﾍﾞﾙ検出
Detect FE : lead-in level
Y
N
S17
UP/DOWN信号停止
Up/down signal stop
S18
FCON

【図6】 Figure 6

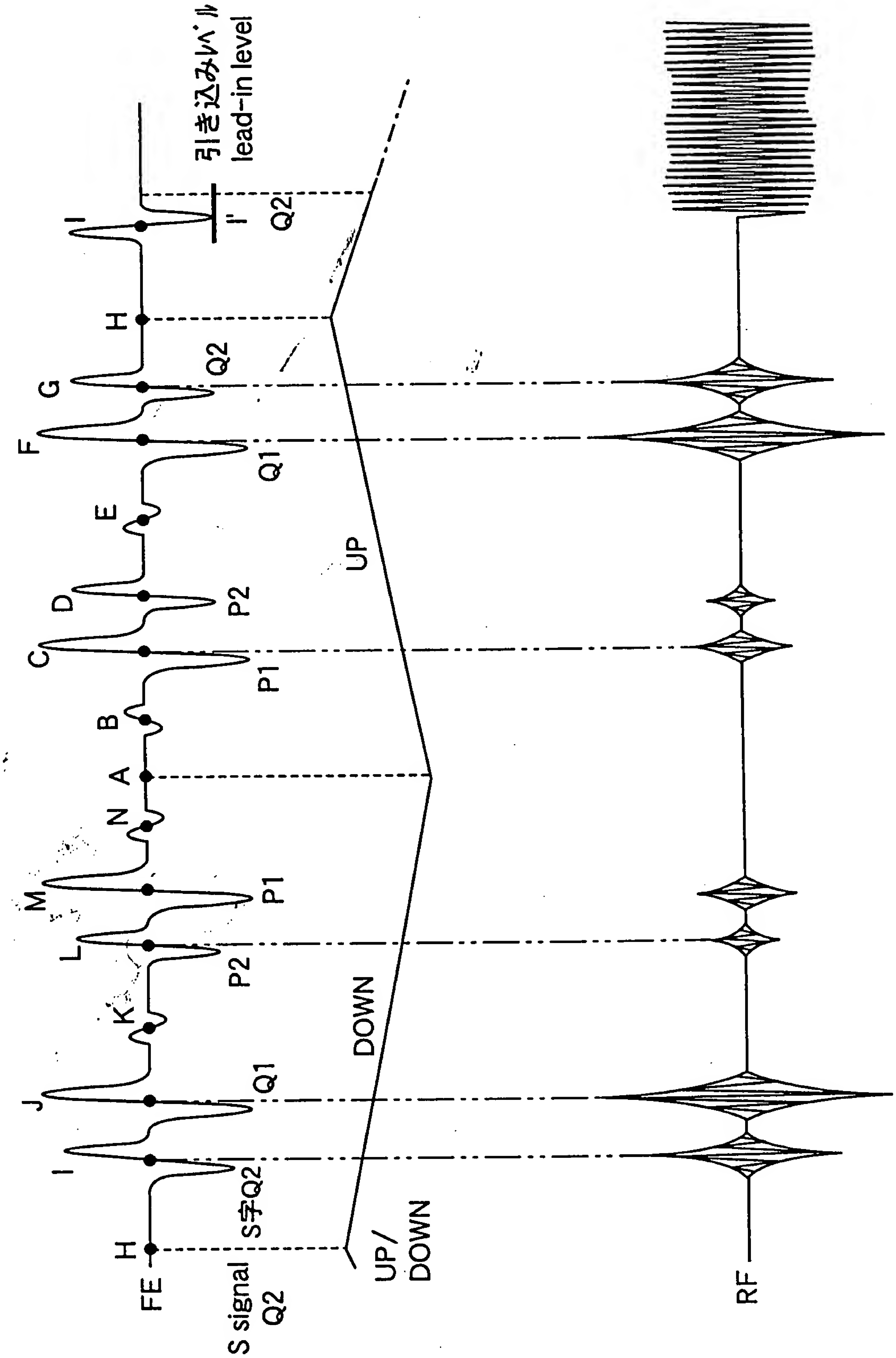


(a)
2層目L1 second layer L1
1層目 L0 first layer L0
(b)
4層目 L3 fourth layer L3
3層目 L2 third layer L2
2層目 L1 second layer L1
1層目 L0 first layer L0

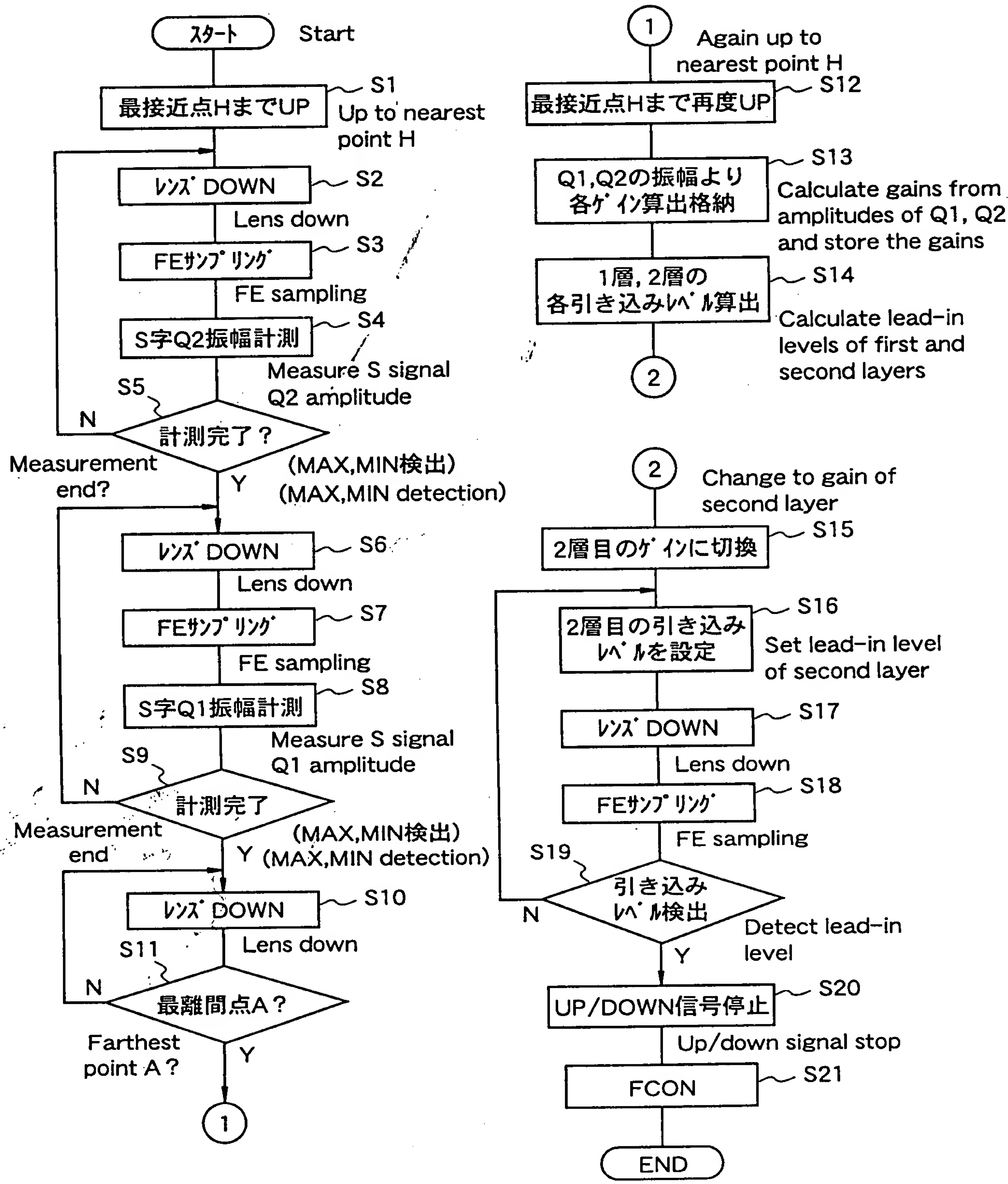
【図7】 Figure 7


FE
O
A
B
S字
S signal
P1
P2
C
D
E
Q1
Q2
F
G
H
I
J
K
L
M
N
UP
DOWN
UP/DOWN
second layer L1
2層目 L1
1層目 L0
first layer L0

【図8】 Figure 8

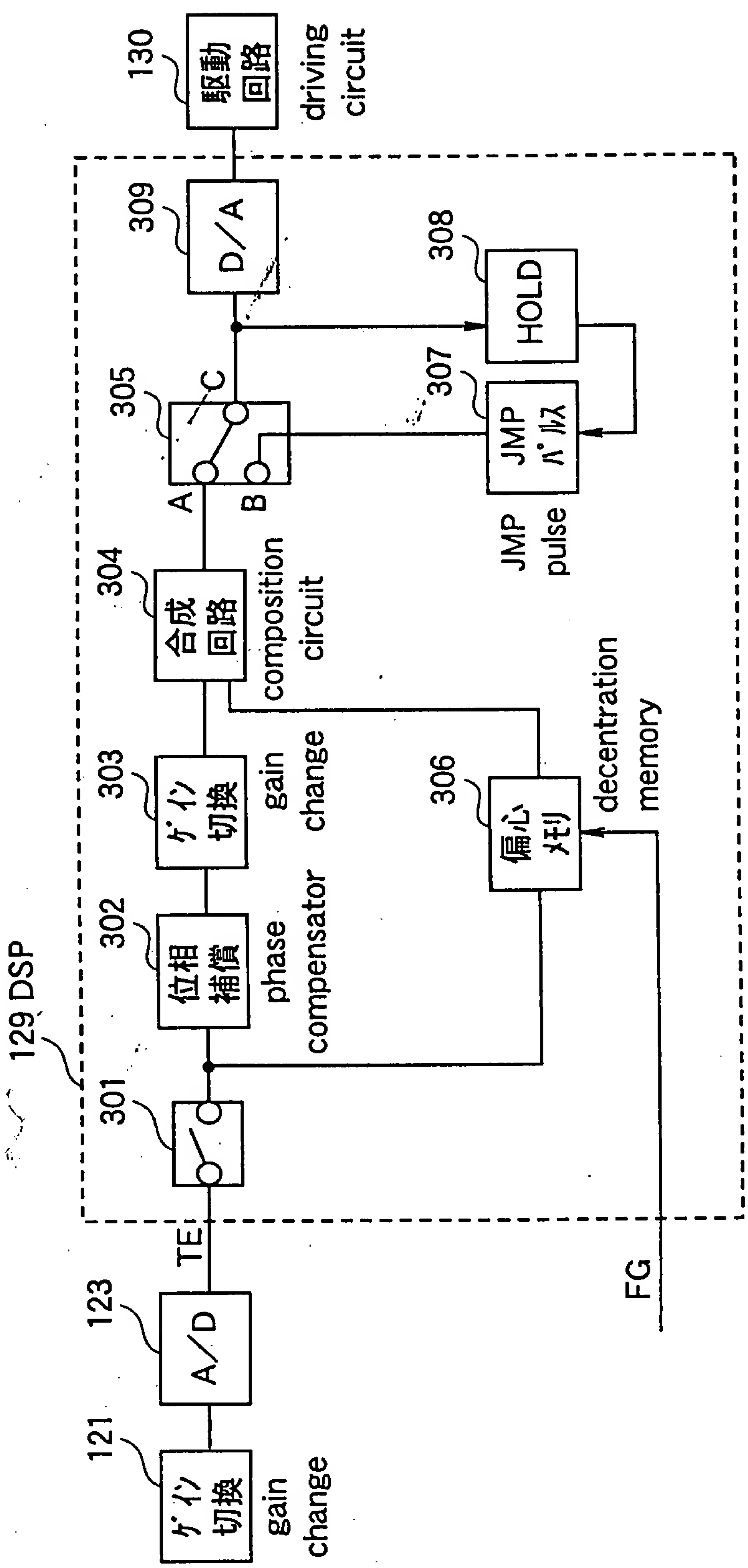

引き込みレベル
lead-in level
FE
H
I
J
K
L
M
N
A
B
C
D
E
F
G
H
I
I'
S signal Q2
S字Q2
Q1
P2
P1
P1
P2
Q1
Q2
Q2
UP/
DOWN
DOWN
UP
RF

【図9】 Figure 9

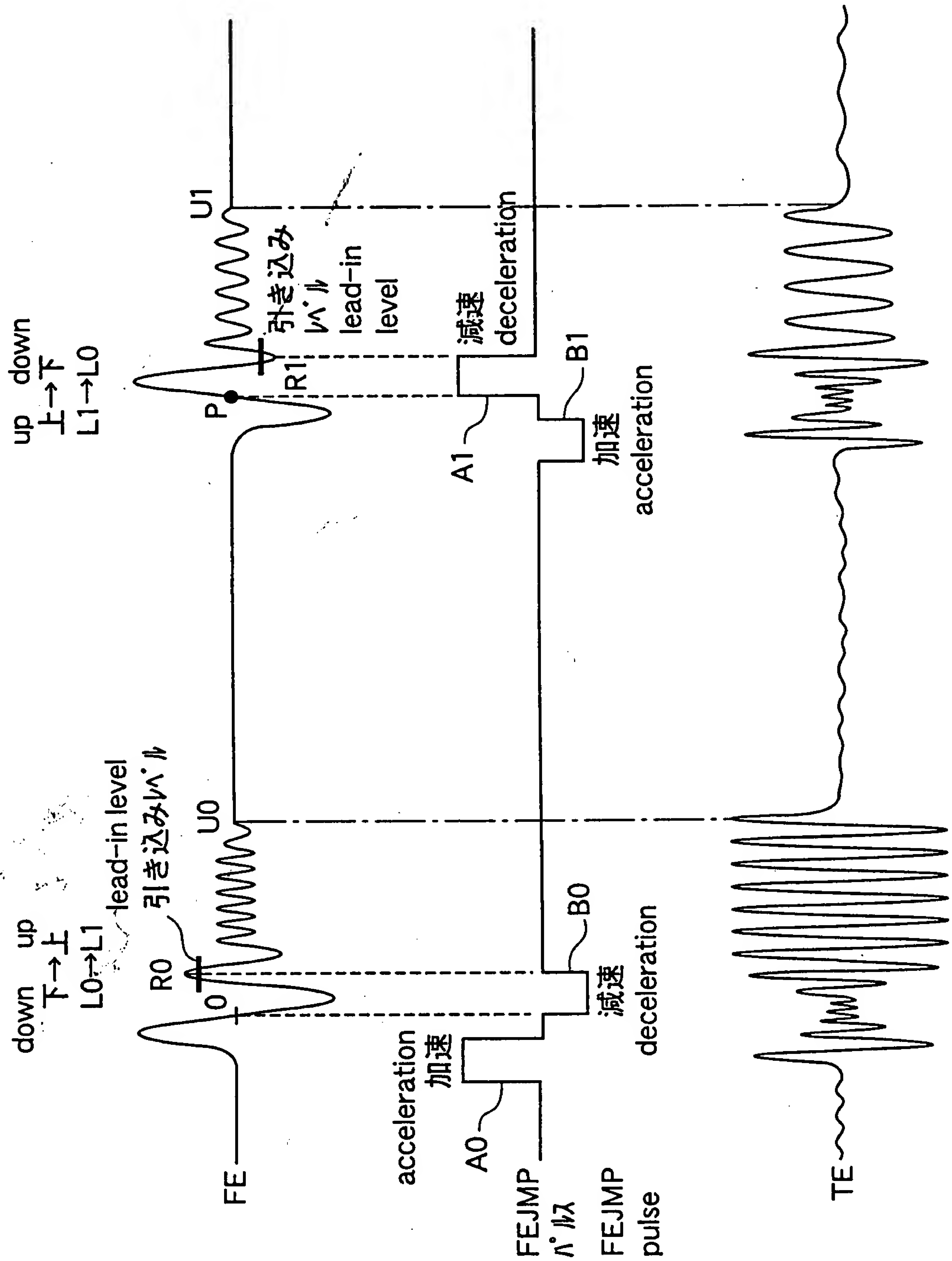


スタート
Start
最接近点HまでUP
S1
Up to nearest point H
レンズ DOWN
S2
Lens down
FEサンプリング
S3
FE sampling
S字Q2振幅計測
S4
Measure S signal Q2 amplitude
S5
計測完了？
Measurement end?
N
Y
(MAX,MIN検出)
(MAX,MIN detection)
レンズ DOWN
S6
Lens down
FEサンプリング
S7
FE sampling
S字Q1振幅計測
S8
Measure S signal Q1 amplitude
S9
計測完了
Measurement end
N
Y
(MAX,MIN検出)
(MAX,MIN detection)
レンズ DOWN
S10
Lens down
S11
最離間点A？
Farthest point A?
N
Y
1
1
Again up to nearest point H
最接近点Hまで再度UP
S12
Q1,Q2の振幅より各ゲイン算出格納
S13
Calculate gains from amplitudes of Q1, Q2 and store the gains
1層，2層の各引き込みレベル算出
S14
Calculate lead-in levels of first and second layers
2
2
Change to gain of second layer
2層目のゲインに切換
S15
2層目の引き込みレベルを設定
S16
Set lead-in level of second layer
レンズ DOWN
S17
Lens down
FEサンプリング
S18
FE sampling
S19
引き込みレベル検出
Detect lead-in level
N
Y
UP/DOWN信号停止
S20
Up/down signal stop
FCON
S21
END

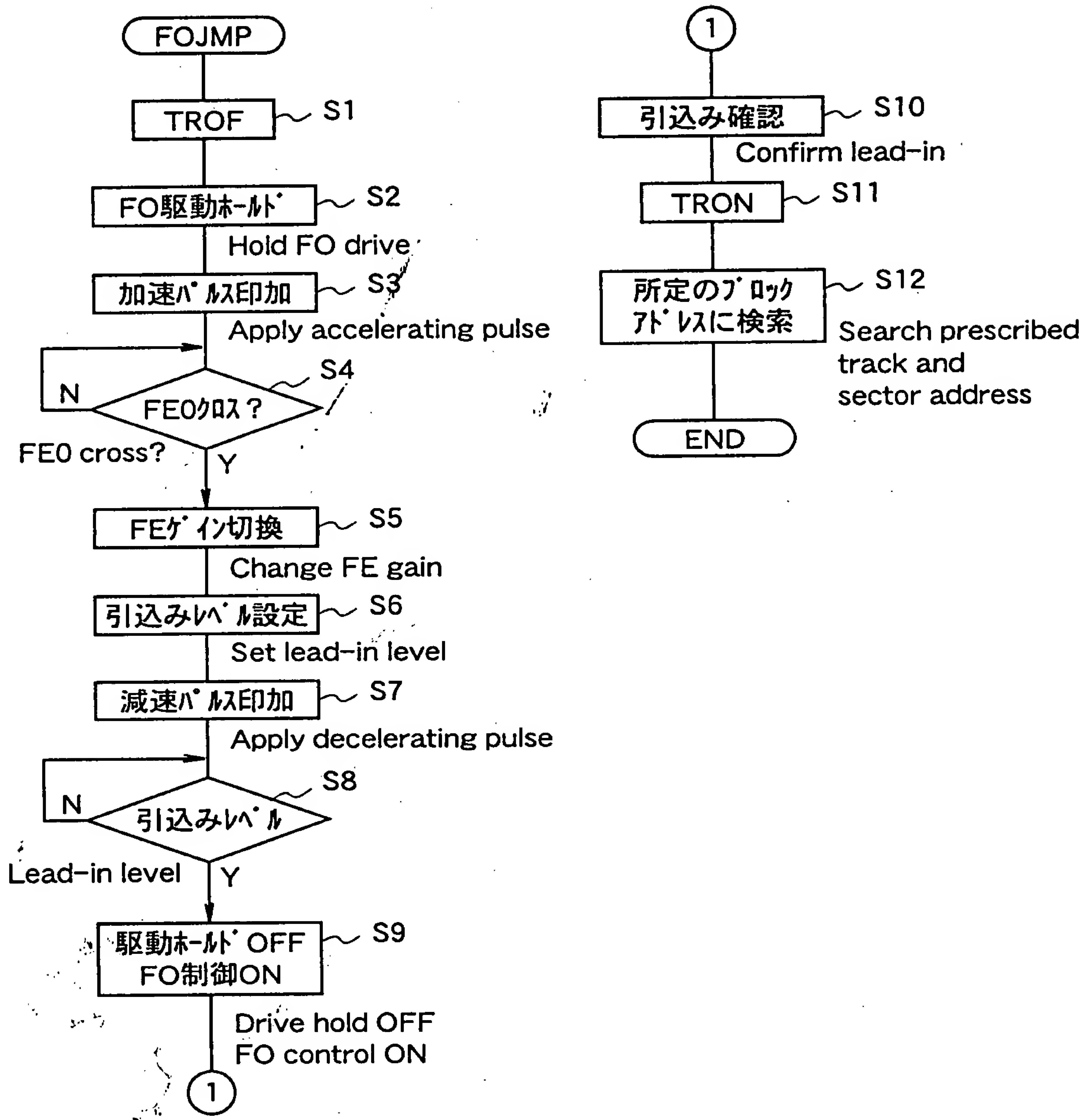
【図10】 Figure 10



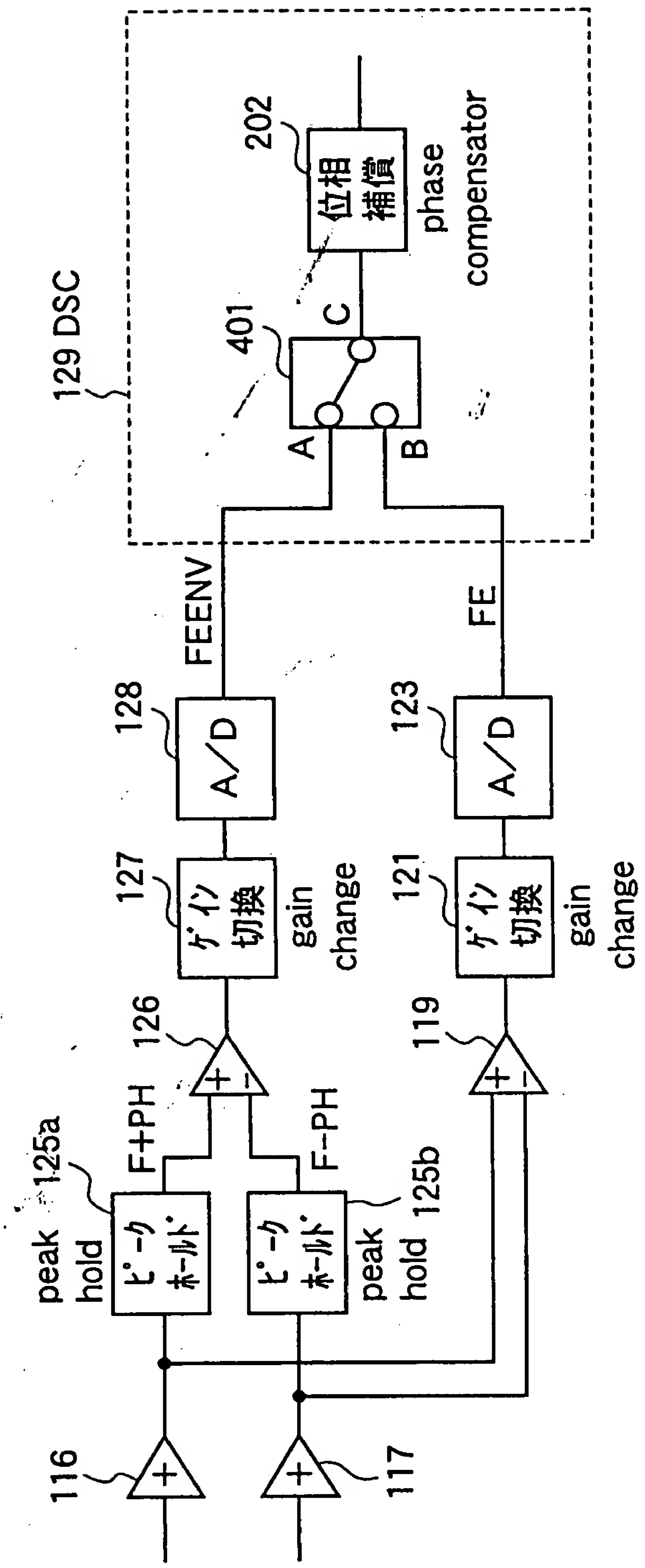
【図11】 Figure 11



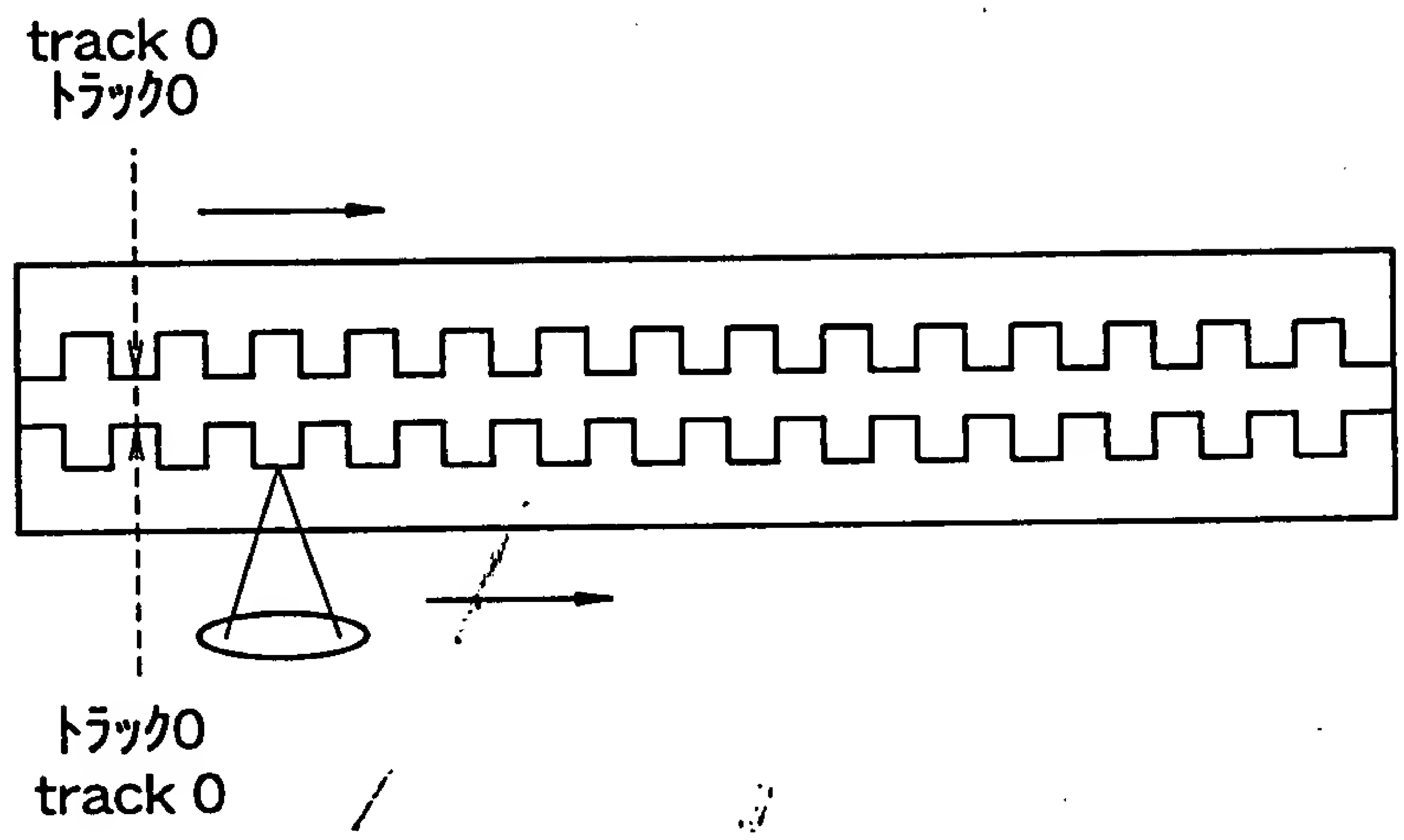
【図12】 Figure 12



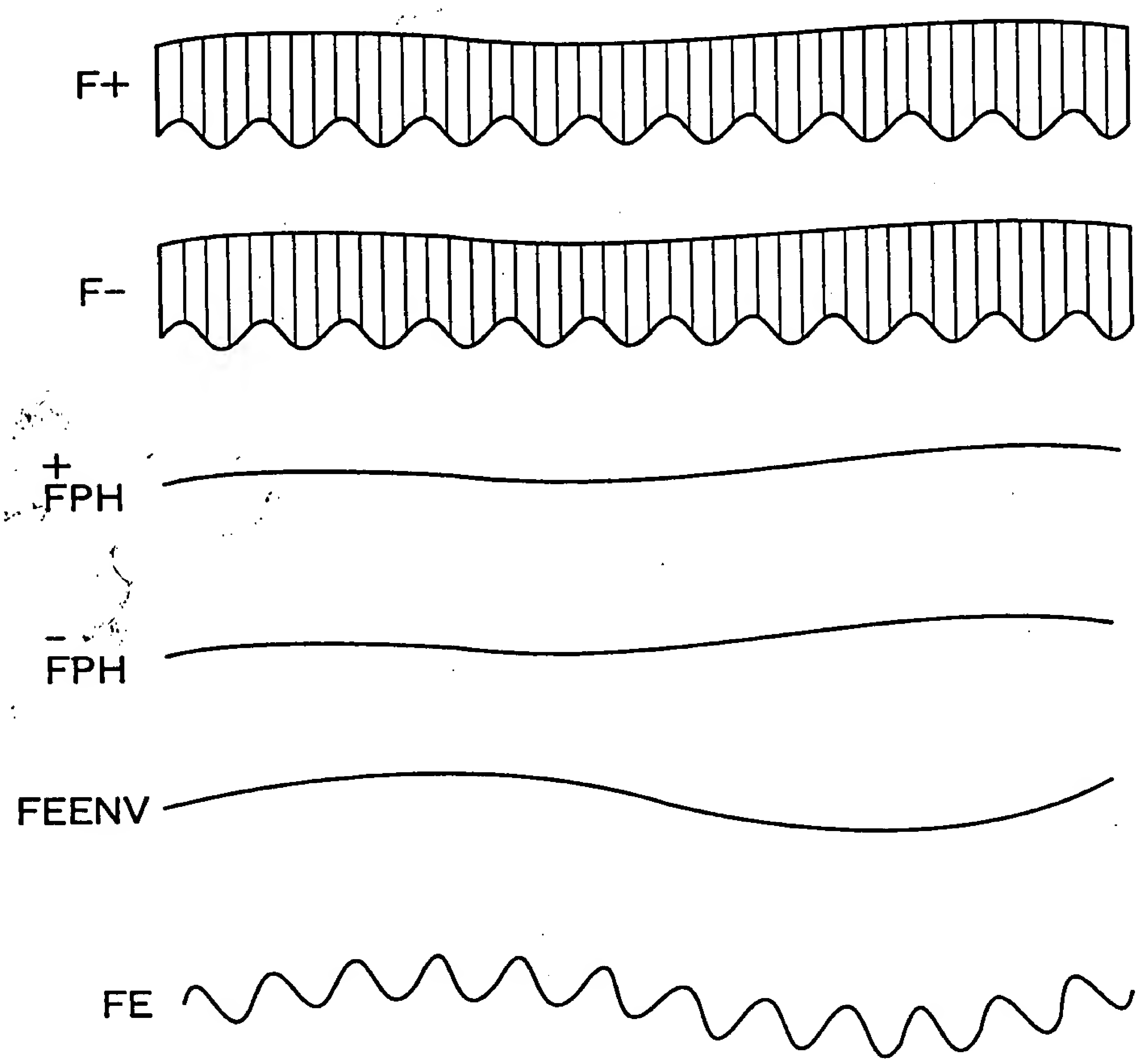
【図13】 Figure 13



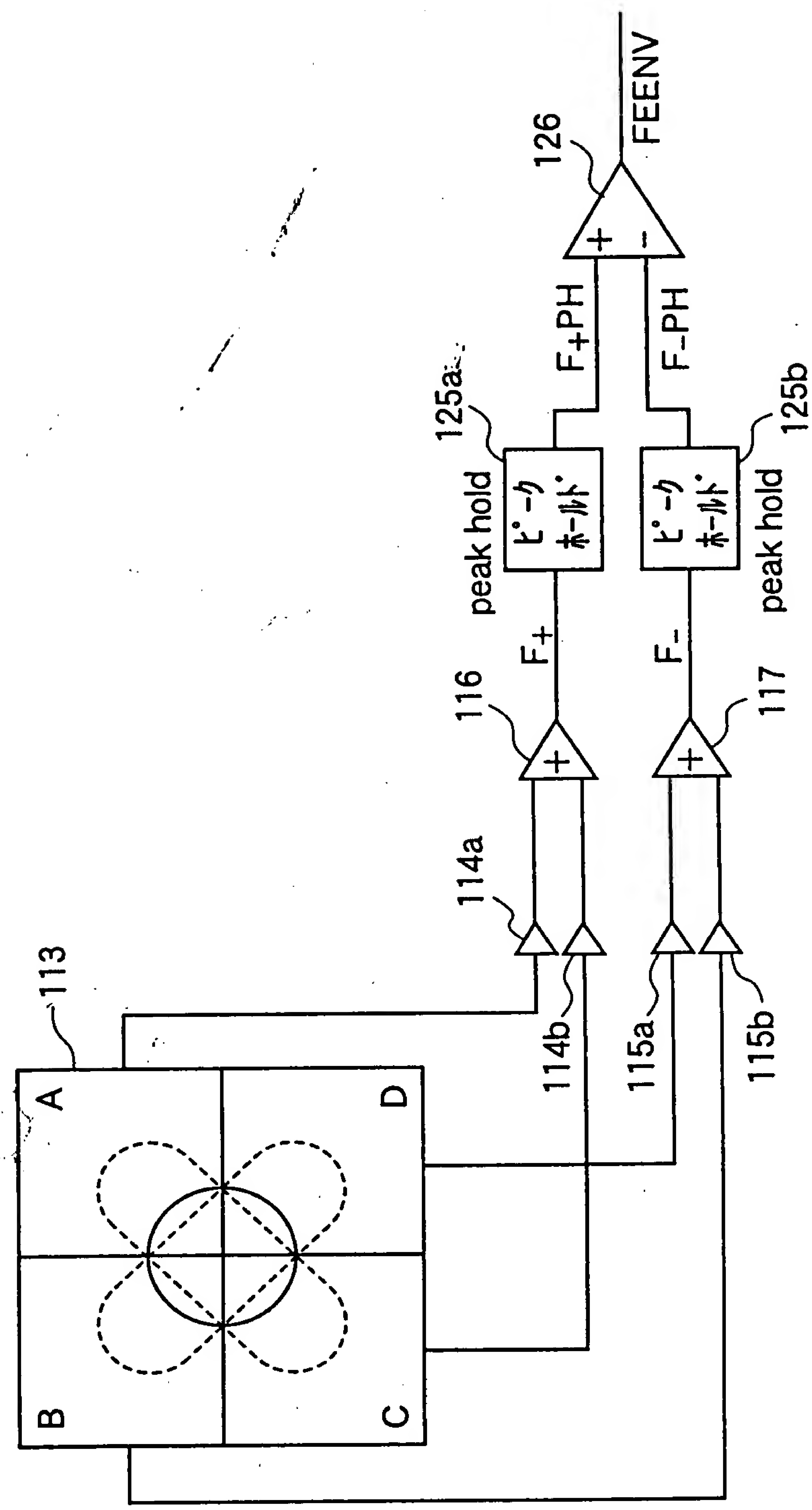
【図14】 Figure 14



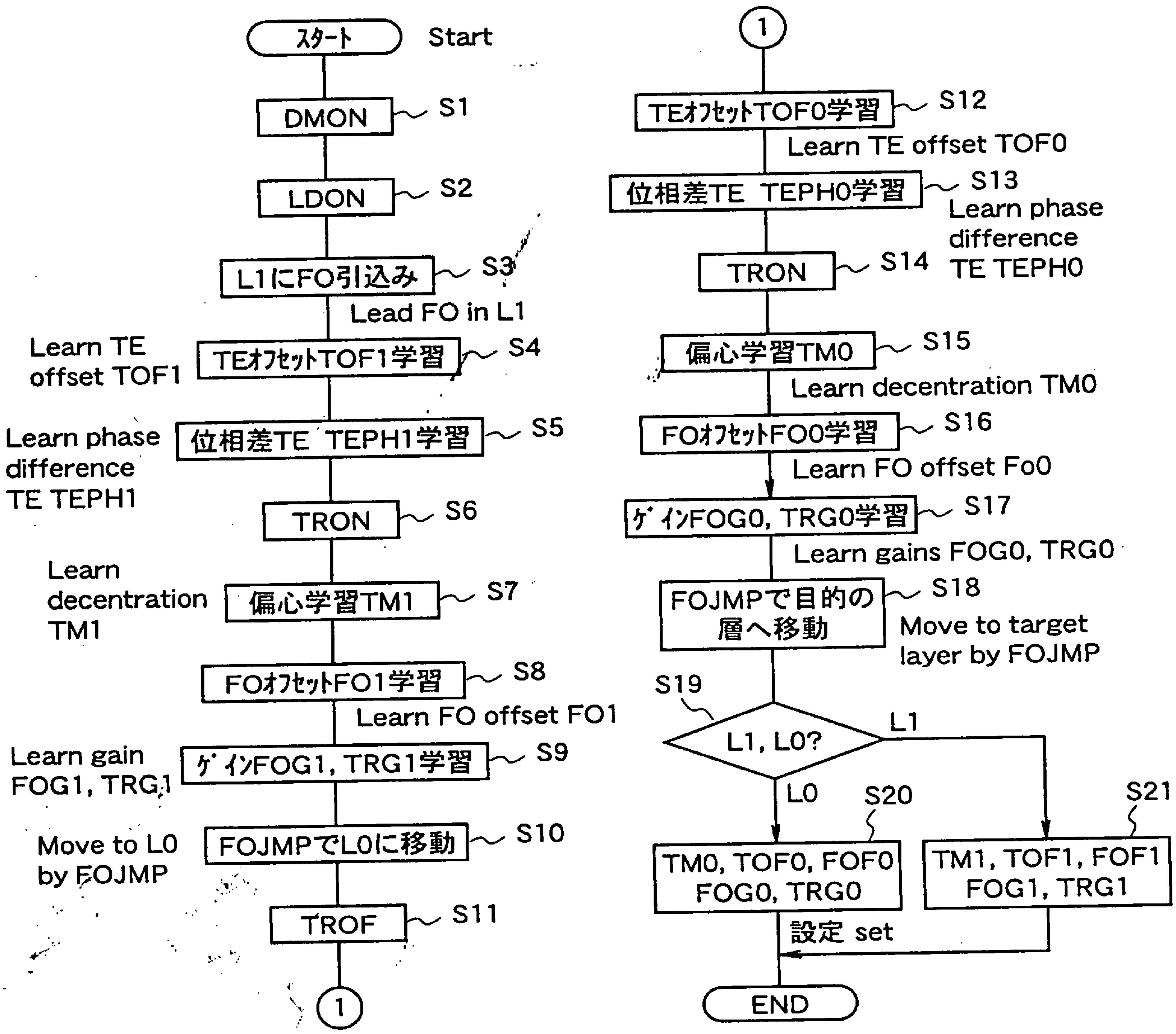
【図15】 Figure 15



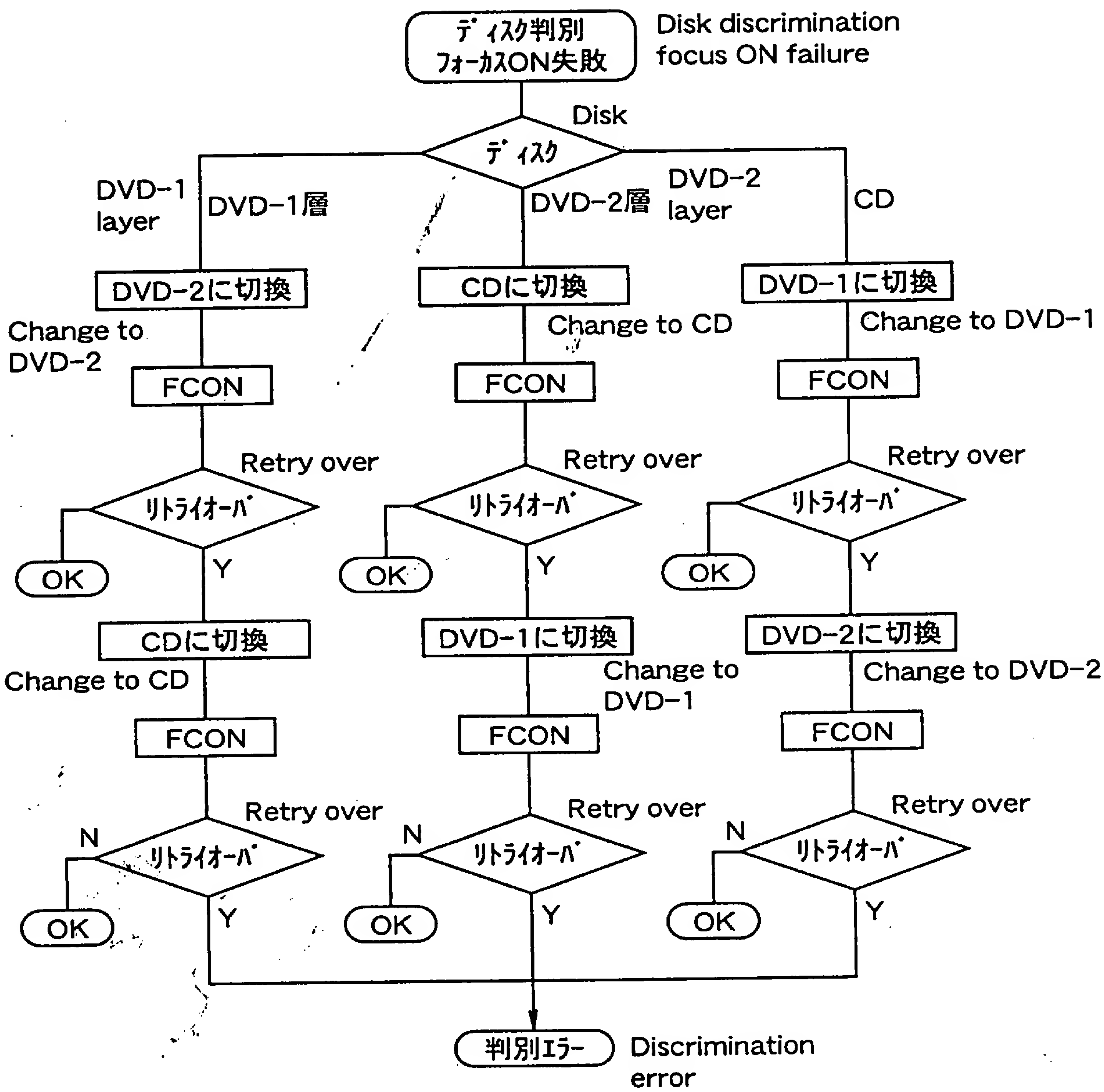
【図16】 Figure 16



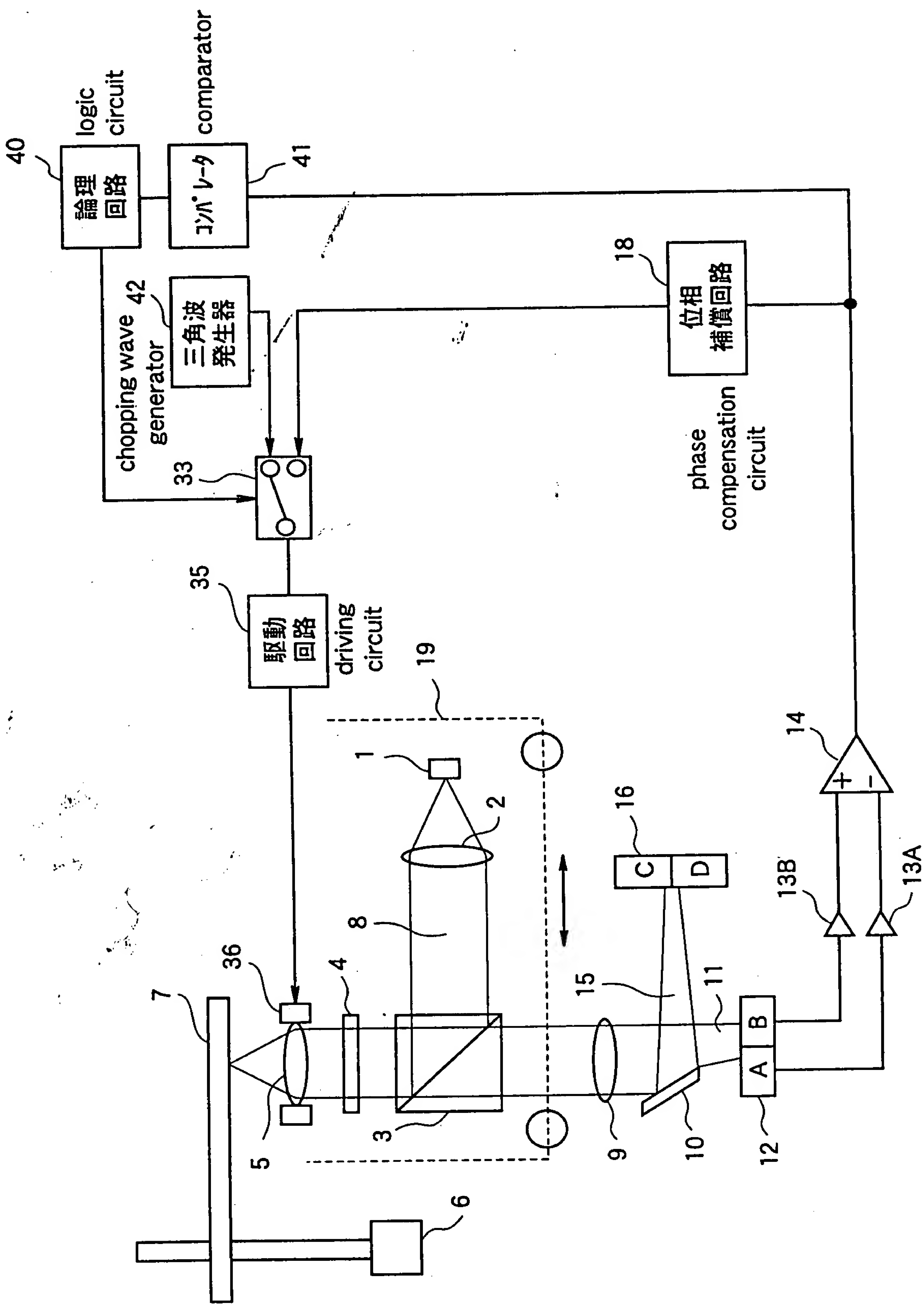
【図17】 Figure 17



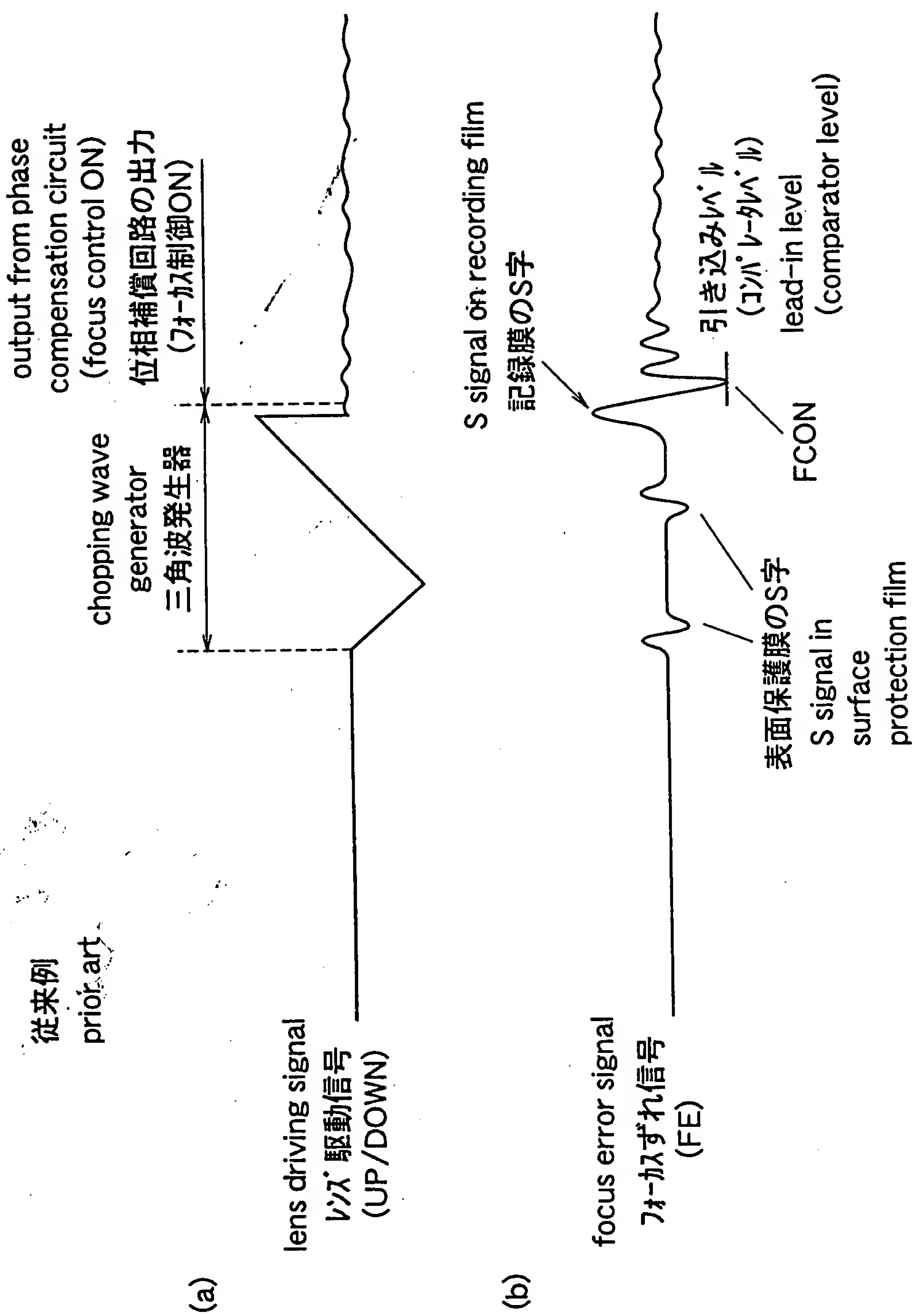
【図18】 Figure 18



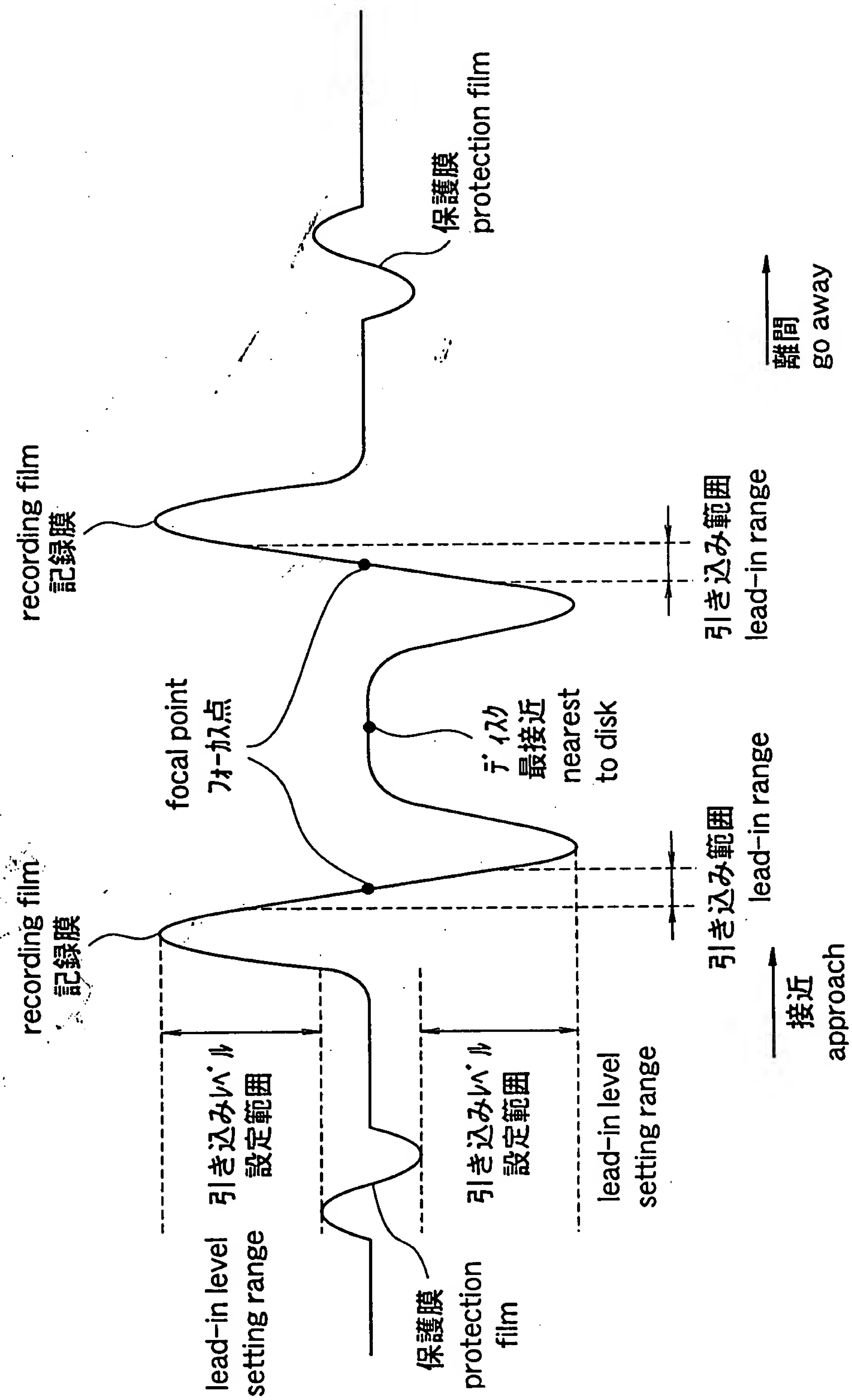
【図19】 Figure 19



【図20】 Figure 20



【図21】 Figure 21



【図22】 Figure 22